JUL -8 1941
TECHNOLOGY DEPT.

July 1941

TECHNOLOGY REVIEW

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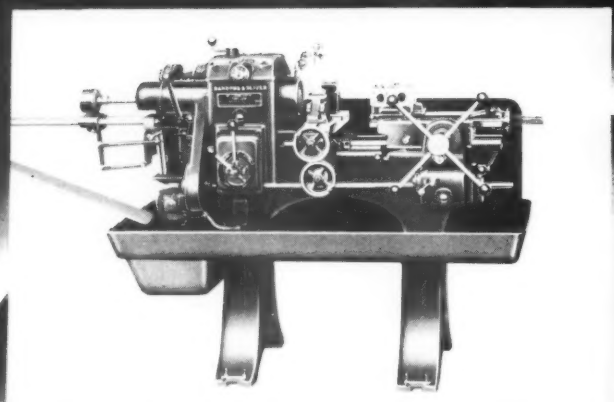

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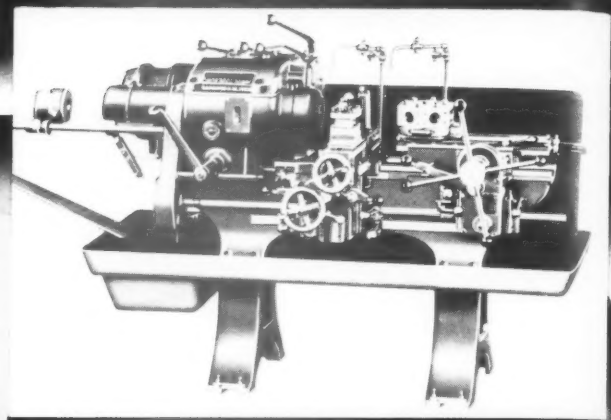

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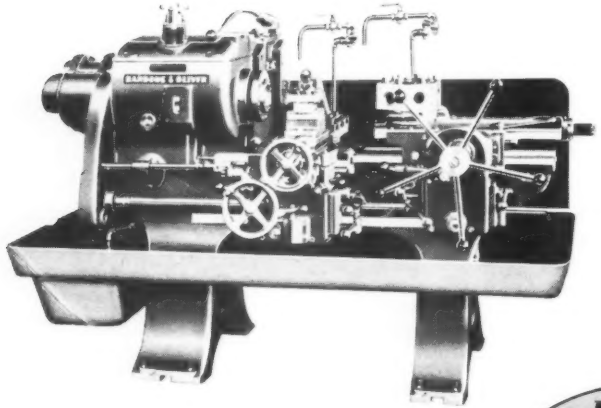

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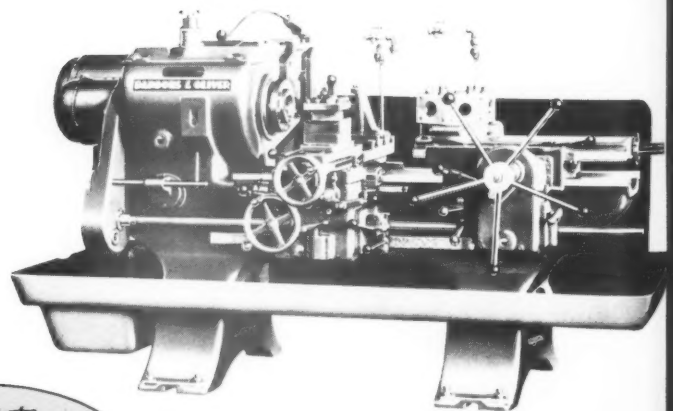

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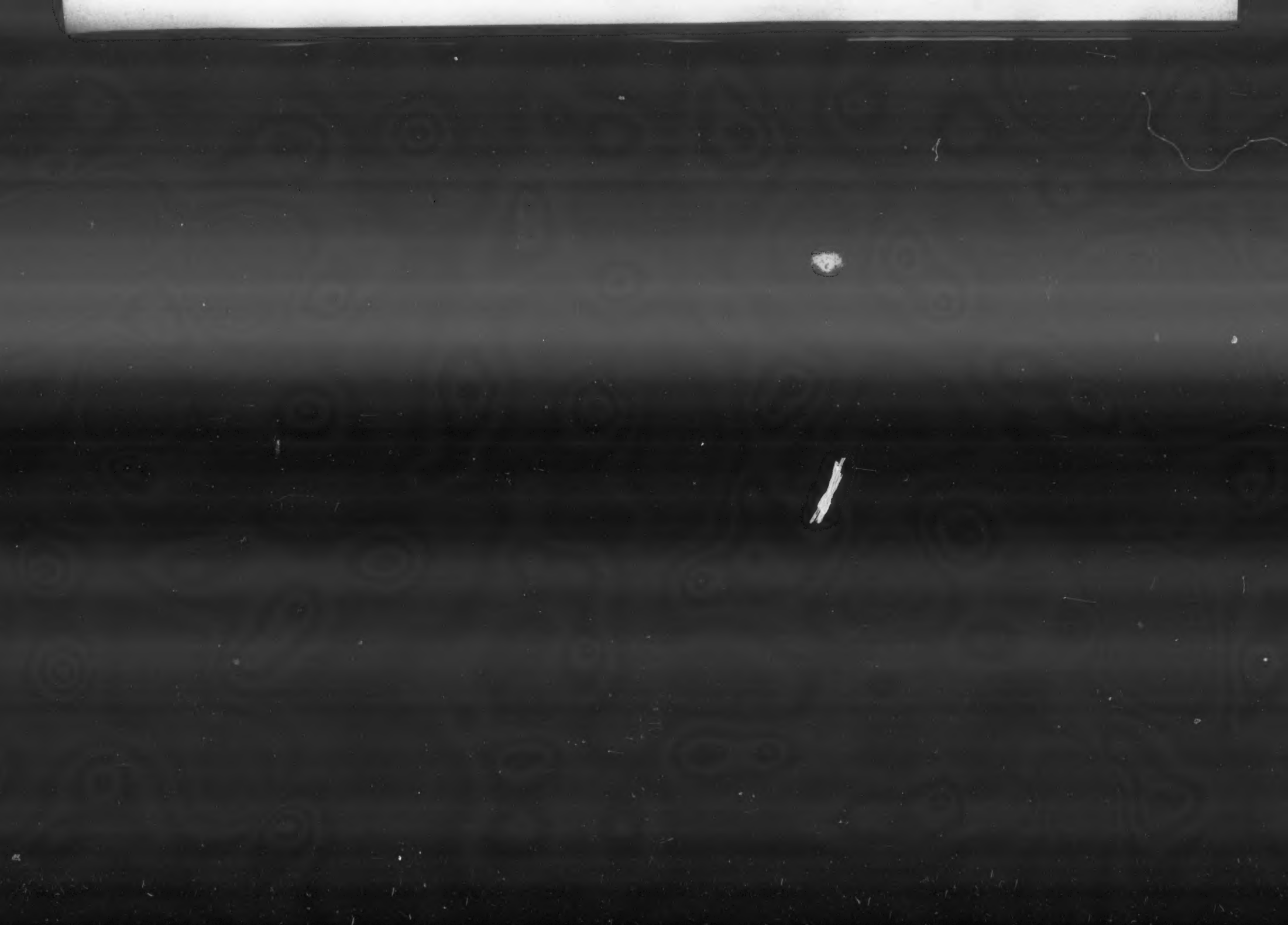

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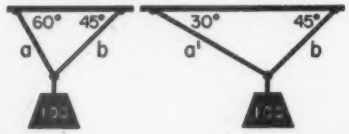
No. 36

Just for Fun!

A CHALLENGE

TO YOUR INGENUITY

A WEIGHT was found hanging on two cables, as shown in the left-hand diagram below. Mr. Dum wanted to alter the arrangement to that shown at the right, without disturbing cable *b*. He figured that the stress in *a'*



would be no greater than the stress in *a*, but when he made the change, the cables broke.

Were his calculations wrong? If not, why did the weight fall?

Answer

Stress *a'* = stress *a*, but stress *b* increases!

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THE TABULAR VIEW

Commencement. — From the ceremonies attendant upon the departure of the Institute's seventy-fourth graduating class — that of 1941 — The Review in this issue presents three articles drawn from notable addresses of the occasion. PRESIDENT COMPTON'S traditional address to the graduating class (page 415) was this year filled with particular meaning. Analysis of the present international situation from the point of view of scientific and technological learning is in itself far reaching; Dr. Compton's discussion goes farther, however, in its evaluation of what present events connote for young men and women. In the baccalaureate address (page 417) ANTON J. CARLSON, distinguished scientist and humanist, professor emeritus of physiology at the University of Chicago, cogently pleads for a broadening of the social base of science, which in itself might be expected to further the aims stressed by Dr. Compton. ROBERT E. WILSON, '16, President of the Pan American Petroleum and Transport Company, emphasizes in his commencement address (page 419) the importance of human values and comprehension of the influence of individuality in affairs.

Medical Means. — The conferences which have come to be a notable part of Alumni Day at Technology each year have especial interest both as straws pointing whither blows the wind of events and as illuminating general discussions of the broad aspects of scientific developments which have wide influence. This year's conference, under the title "Science and Engineering as Allies of Medicine," well met both these qualifications. It brought to the speaker's stand three distinguished scientists, whose papers are presented in full in this issue of The Review. FRANK H. LAHEY, the noted surgeon who directs Boston's Lahey Clinic, surveys (page 422) accomplishments of science in medicine as they appear to one actively engaged in practice and widely acquainted with the field. Dr. Lahey has recently been elected president of the American Medical Association. To describe and explain some of the principal instruments which physicists have devised and which physicians have been quick to employ, the conference had Technology's Director of Applied Physics, GEORGE R. HARRISON, Rumford Medalist in 1939, inventor, author known for his ability to make the intricate interesting. Professor Harrison singles out for consideration (page 424) three particularly (*Concluded on page 404*)

The Review is not published during the summer months following July. This issue, therefore, concludes Volume 43. Number 1 of Volume 44 will be published on October 27 and dated November. Readers who bind their copies are reminded that if they possess nine issues of Volume 43, their files are complete. An index to the volume will be ready on August 15 and will be supplied post-free upon request.

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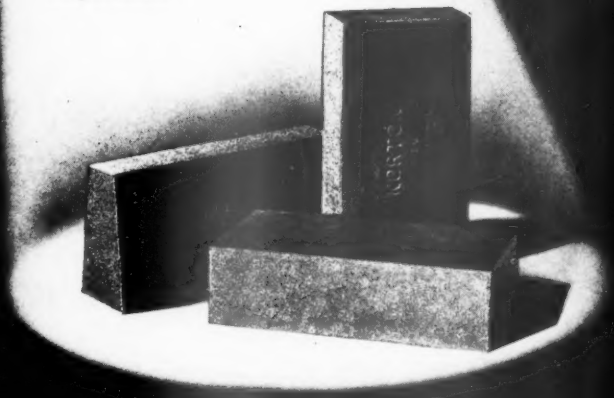

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MAIL RETURNS

Too Few Verbs?

FROM FRANK C. CALKINS:

Having recently criticized a good many scientific manuscripts, I was interested in the article, entitled, "A Word for It," on page 342 of your June issue. The first and apparently the main point in the article is that scientific writers use more technical terms than are necessary. Another point is made, of course, but might perhaps have been more strongly emphasized: that much of the obscurity of scientific writing is caused by unskillful choice and arrangement of everyday nontechnical words. "And" is not a technical term, even in a patent, but it is one of the words most commonly misused. The long sentence you quote about the hour glass contains only two technical terms, "origin" and "rest-mass," neither of which need puzzle a person who read the original article; the obscurity of the sentence is due mainly to bad structure.

A more specific question is raised by your last paragraph. Adjectives have not struck me as overabundant in the manuscripts that I have criticized. Rather, the part of speech used to greatest excess has seemed to me to be the noun — especially the abstract noun. You quote Boder as comparing the proportion of adjectives to verbs. A better term of comparison might have been the total number of words. The ratio of adjectives to verbs can of course be decreased by increasing the proportion of verbs, and this result can be accomplished in a measure by using, instead of abstract nouns, the verbs from which those nouns are derived. In short, it seems likely that scientists use too few verbs rather than too many adjectives. . . .

Washington, D. C.

Roses

FROM BEVERLY DUDLEY, '35:

It is essential that I take a few minutes in an otherwise busy day to offer you (symbolically, of course) a handsome wreath of roses for the June issue of The Review. Each and every one of the articles was a prize, and the organization, selection, and editing of the various articles did much to enhance each story and produce a more effective issue as a whole. . . .

New York, N. Y.

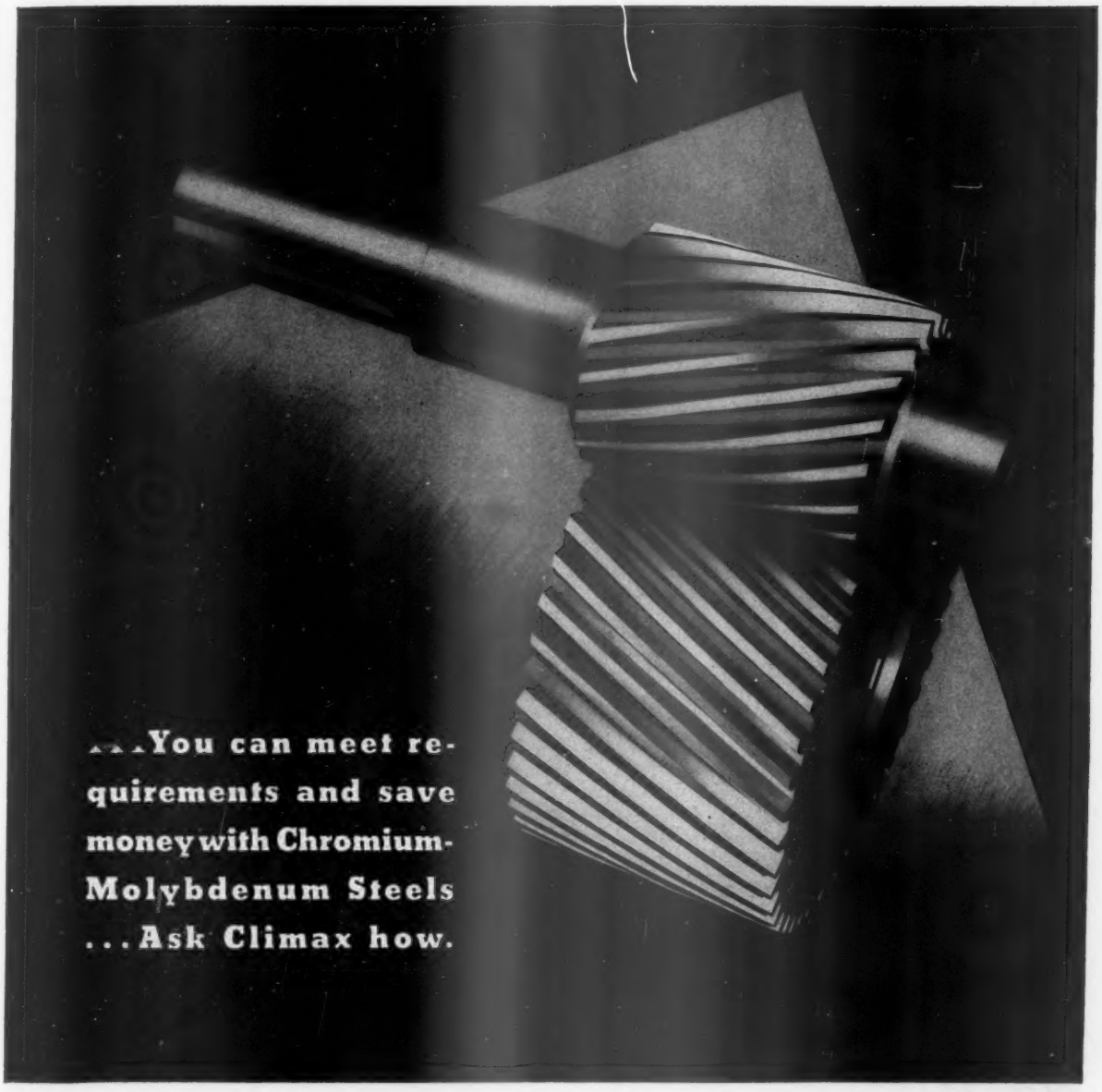
THE TABULAR VIEW

(*Concluded from page 402*)

important tools which medicine has available as a result of the physicist's explorations. Discussing the future opportunities of the physical sciences in medicine, DETLEV W. BRONK, the scholarly chairman of the department of physiology and biophysics of Cornell University Medical College, stresses (page 426) the interrelation essential in beneficent science. For readers who wish to go farther with the topic, MARGARET PAIGE HAZEN of the Institute Library provides (page 428) a thoughtfully compiled reading list.

Cover Club. — To the Cover Club in June came CHESTER H. POPE, '09, who is followed this month by WILLIAM G. DE HART, '44.

Retrospective. — As Volume 43 is concluded, The Review offers thanks for the faithfulness of Class and Club Secretaries and for the constancy of Editorial Associates who have assisted in providing readers this year with added pages equaling an extra issue.



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GOODYEAR

JUL -8 1941

Edwin Way Teale

A tapestry of bees

VOLUME 43 NUMBER 9

THE TECHNOLOGY REVIEW

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EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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From a photograph by William G. de Hart, '44

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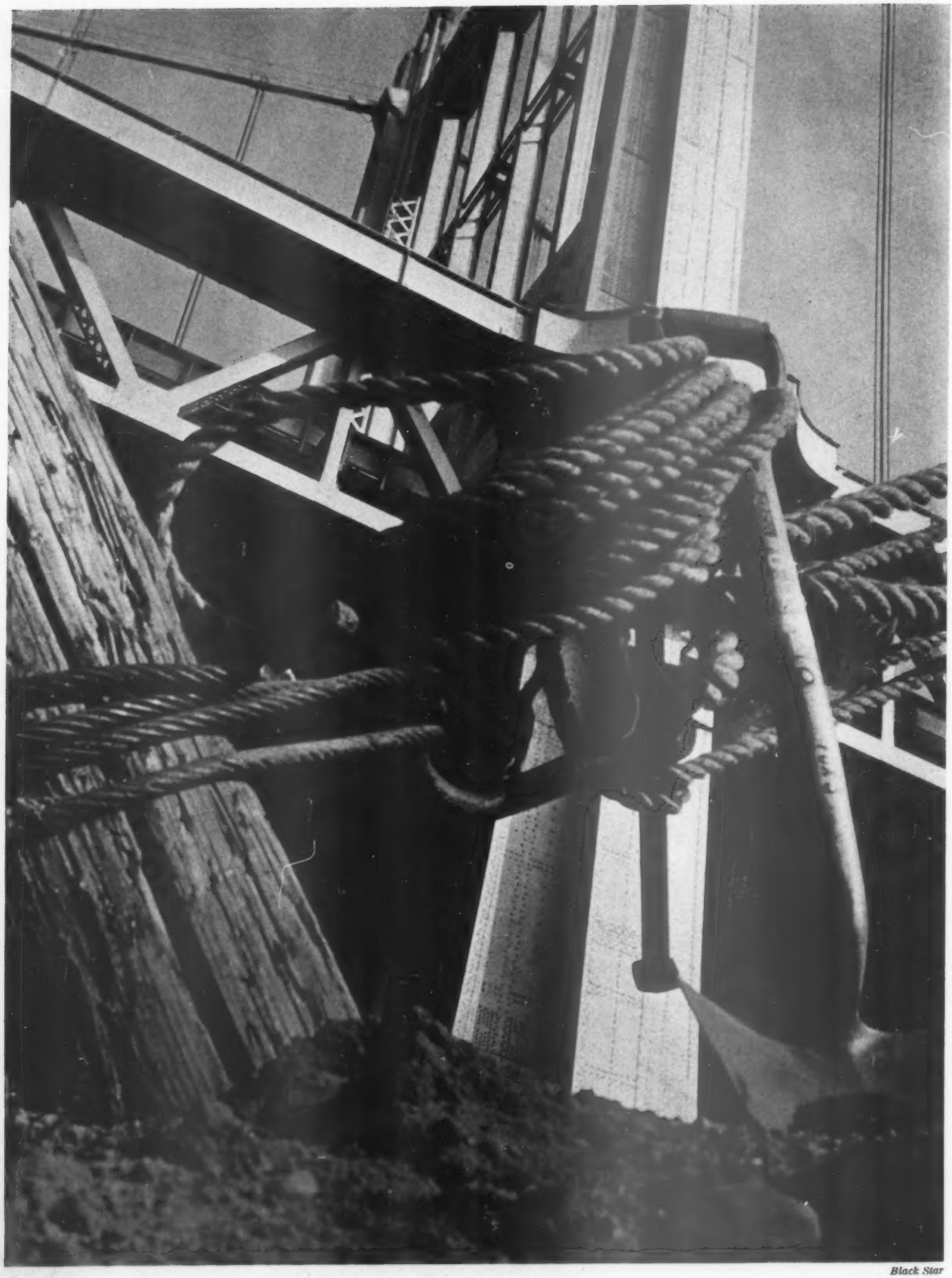


Black Star

Strain against strain, that the bridge shall rise

THE
TECHNOLOGY
REVIEW

Vol. 43, No. 9 July, 1941

The Trend of Affairs

Camouflage

SOME of us can remember the spectacle of wraith-like, zebra-striped ships slipping through the raw mists of the North Atlantic in 1917 and 1918. We may have wondered even then to what extent the striping did in fact bewilder the enemy. Today we can have no doubt that such a simple device as razzle-dazzle would be ineffective against a foe who can approach from below, from the side, and, most important of all, from above, and who can see with more than his own eyes — with the lenses of a camera which may be filtered to separate the razzle from the dazzle. If camouflage is of any present importance, a more technical approach is required. We may well agree with a British author who mourns that though feminine camouflage in the shape of the lipstick has had millions spent on it, the more serious camouflage of the present is a child suffering from arrested development.

At precisely this moment, then, special interest surrounds the appearance of a bulky, scholarly, interesting, and instructive book, *Adaptive Coloration in Animals* * by Hugh B. Cott, lecturer in zoology and Strickland curator at Cambridge University. In it he demonstrates quite clearly that the devices of man "are merely rediscovered arrangements and applications of colour" long ago known in nature — and usually more specialized in nature. A parallel exists between the hunting disguise of a primitive man and the concealed machine-gun post of the enlightened citizen of today; and the policeman's white gloves were worn long ago by the polecat.

Cott's book is serious as well as entertaining. From a biological point of view, its chief importance may well be in the problems posed for the geneticist by its complete presentation of the facts of cryptic warning and mimetic coloration. Much interest is in the experimental information the book presents on the degree of immunity provided by natural camouflage. This information is important, because adaptive coloration has often been singled out as a major object for attack by antiselectionists.

For our present purposes, however, discussion may rest on Cott's consciousness of the parallelism between the interests of his field and those of the *camoufleur*. The parallelisms are by no means complete. From a fully military point of view, the camouflage of mobile objects may have a close relation to the camouflage of the equally mobile deer or moth. But no animal remains stationary forever; no predatory beast has a co-ordinate map of the location of his prey. It is under such additional risks that camouflage must be provided for fortifications, for essential installations of various kinds, for industrial property.

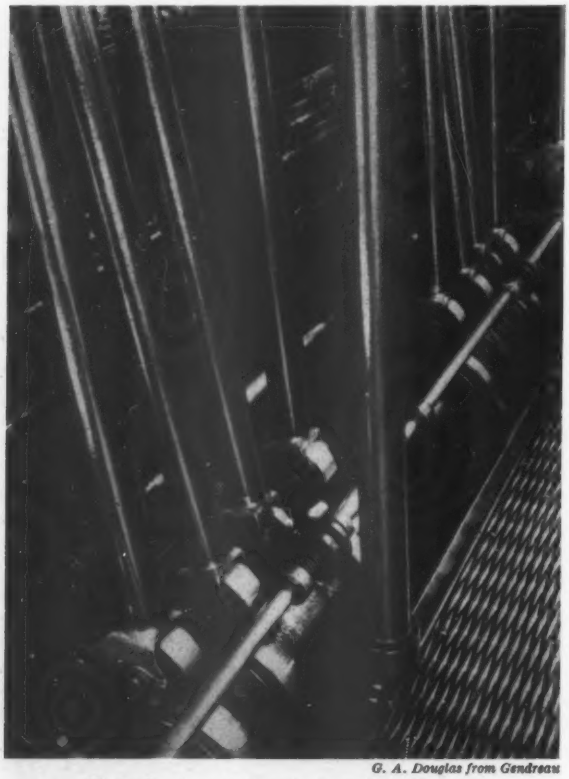
In the application of camouflage to fixed objectives, the purpose of camouflage must be conceived properly. With the best bombing sight in the world, a bombardier must for success still enjoy several miles of level flight, must know accurately his altitude, his speed, his drift. Very small changes in any of these factors will cause him to miss. The first and most important way to make him miss is of course to shoot at him, to give his pilot some concern. Beyond that, if one can create in the bombardier's mind a moment's hesitation as to the precision with which he has selected his target, one may cause him to miss. For the creation of that hesitancy, camouflage of well-known objectives can best be justified. On the other hand, uncertainty will not cause him to miss the entire landscape; his bomb will still be released. Hence camouflage can scarcely be justified when the thing to be concealed spreads over a wide area and when a hit on any portion of it will cause equally serious destruction.

*London: Methuen and Company, Ltd., 1940. xxxii+508 pages. 40*s*.

Within this framework we may find in nature every principle of camouflage which might profitably be applied today. Adaptive coloration in nature may be for concealment or warning and in either case may be a weapon of offense or defense. To scare the human enemy by human camouflage is hard, though perhaps not impossible. The bigger share of the art will be applied to concealment; moreover, though Birnam wood may again come to Dunsinane, it seems that camouflage will be more a weapon of defense than of offense.

From an optical point of view, visual clues are of four kinds: hue and tone, light and shade, surface and contour, and shadow. Each of these may be concealed or at least confused by methods already well known in nature. All must be concealed if camouflage is to be effective.

Most familiar of nature's protections is that of concealment by general color resemblance to the background — the green of the tree boa, the dun of the desert jackal. But man must make his color similarity prevail to the color-blind as well as to him of normal vision, in darkness or in light, and even in selected portions of the light band, such as the ultraviolet and especially the infrared, which may be used to trap the unwary *camoufleur* through photography. Nature has approached even this latter problem. Some tree frogs, for example, whose green color is due to a combination of pigment and structure, have skin which, in an infrared picture, looks as though it were colored by chlorophyll. In other words, the concealment is quite as good under infrared light as it is under normal light, if not better. This fact is significant, if, as many naturalists believe, there is a possibility that some animals — owls, for instance — have a visual range which extends to, or within, the infrared region of the spectrum.



G. A. Douglas from Gendreau

Verticality in a section of a large Diesel engine

Even when a body is the same color as its background, however, shade will cause it to be detected, for shade will give the appearance of projection or depth. Place a white object against a white background and then so light the object that portions are in shade. There is no device by which such parts can be made white enough for concealment, since nothing is whiter than white. Let the object be brown and it will then be conspicuous, but in a lower key. With this lower key, the effect of shade and light can be counteracted. This is of course the reverse of the art of the painter, who, by use of light and shade, "creates upon a flat surface the illusionary appearance of roundness." By countershading surfaces not normally directed toward the source of light and by counterlighting those in shade, we may create something approaching optical flatness. Airbrush accuracy of shading is seldom approached in nature, but such accuracy is quite unnecessary. Seurat, the greatest of the pointillist painters, showed how easily any effect of color or shading could be produced by proper selection of combinations of dots of primary colors. Likewise in nature one may note the change in spacing of the hyena's stripes, from front to rear. At a distance, countershading is possible by many graded combinations which may in themselves be purely geometrical. The demonstration is so common in nature that further examples need not be cited, yet it may be noted that in some transparent fish, countershading is extended even to the opaque internal organs.

Objects have continuity of surface. For good concealment this continuity must be destroyed, and it frequently may be by patterns based on a psychology which says that if the eye of the observer is drawn to the patterns, it will be diverted from the shape which bears them. To be effective, such patterns must evidently contradict the form and not follow the anatomy. This aspect of camouflage was the dazzle of the last war. Of the results then or of the timid painting of today, Cott has low opinion. Disruptive painting, he says, "must be carried out with courage and confidence, for at close range objects properly treated will appear glaringly conspicuous. But they are not painted for deception at close range, but at ranges at which big gun actions and bombing raids are likely to be attempted. At these distances . . . mere blotches of brown and green and grey . . . blend and thus nullify the effect and render the work practically valueless. . . ."

With many cryptic animals the shadow may be more conspicuous than the animal which casts it, as is obviously true of camouflaged buildings as well. The character of shadow depends naturally on the surface on which it falls and is of great importance to those animals who seek protection from marauding birds or from the camera on wings. Animals of compressed form orient themselves to the sun to cast the least shadow, or tilt their wings in such a way as to conceal the shadows they cast. Animals of depressed form scoop themselves into their background. This is the German method of camouflaging roads with screens above them

Rectangularity. The wild waves were all cross talking when Erwin Haskell Schell, Jr., son of Professor Erwin H. Schell, '12, photographed them about four-thirty one afternoon this spring from the North Shore above Gloucester, Mass.

simulating the concealed road and making it appear void of traffic. Such a screen would cast a shadow save for the fact that gently sloping side screens merge it into the surroundings. Again, while actual shadows may be effaced, spurious ones may be suggested.

Cott is in this book acting primarily as naturalist and only incidentally as *camoufleur*. Hence he may be forgiven for failing to stress one very important point about human camouflage. The tricks which nature has provided for her progeny are in tune with a master plan. The form of the scarce-tissue moth would help it not a bit were there not specialized bark against which the moth can hide; the gray of the East African tree frog would be dangerous to it on a green surface. Nature has a plan. All too often human camouflage has started without a plan or has asked the *camoufleur* to exercise his tricks on a plan which in itself tended to defeat all the versatility of the man. If camouflage is important, the plan of an installation must accept the later application of camouflage as one of the important criteria in determining design.

All these considerations suggest that we may have come a long way in a new science since the days of razzle-dazzle. They show how readily the knowledge of an apparently unrelated field of science may be applied effectively in another area. The British have recognized this fact clearly enough. Julian Huxley tells us in his introduction that Dr. Cott has been "called on to apply the principles he has studied to such good effect in animals to the practice of camouflage in war."

Identification Tags

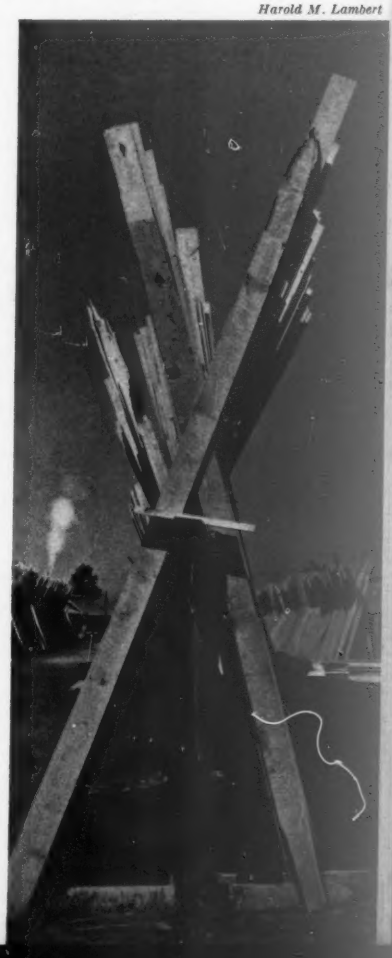
THE migration of man has been kept track of fairly well for some time, an accomplishment made possible by visas, passports, police checkups, and other formalities induced by the crossing of frontiers. Other mammals, however, as well as birds and fish, are not known to visit a consular office previous to undertaking their journeys, and the charting of their complex and often immense wanderings must be done by the forcible attachment of identifications.

North America has at present about 2,100 bird-banding stations, the bulk of them in this country under the control of the well-named United States Bureau of Biological Survey. At these stations approximately 300,000 birds are being tagged each year with aluminum bands. On the average, 20,000 of the tags are recovered. The number so far tagged all over the world runs well into the millions. This simple technique has been the primary means of uncovering the multitude of migration patterns now known and has also thrown much light on the length of life of birds and on their family habits. Although intensively used for a comparatively small number of years, the practice is quite old, the earliest procedure being to clip or paint feathers or occasionally to tie a parchment memorandum to the bird with silk thread. The first use of a ring or band dates from 1710, and as early as 1803 Audubon was marking birds with silver threads. The use of materials with relatively great durability and resistance to atmospheric attack is clearly important.

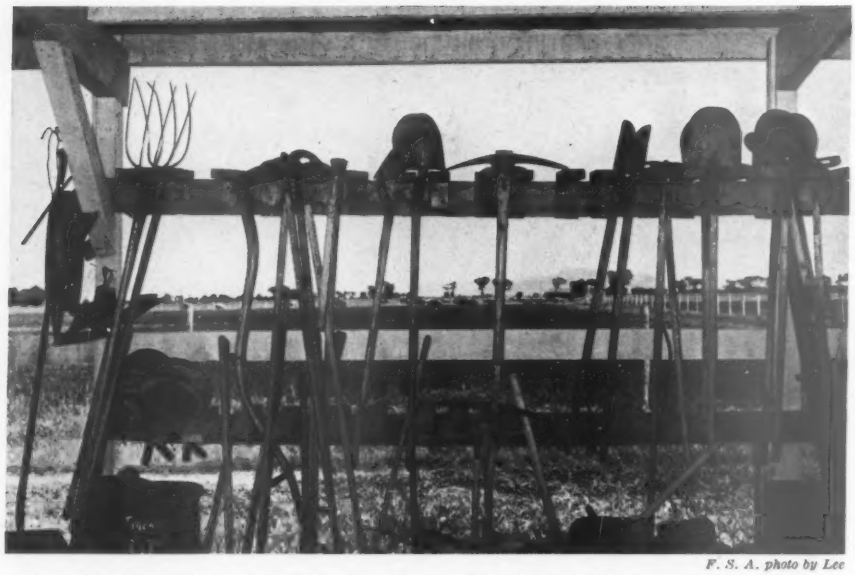
Among the more remarkable feats disclosed by bands is that the ruby-throated hummingbird drives straight across the Gulf of Mexico in a 500-mile jump and that the golden plover apparently migrates from Nova Scotia to South America in a single nonstop flight of 2,400 miles, losing about two ounces of body fat in the process. But the prince of wanderers is the arctic tern, which annually moves from the arctic to the antarctic via Europe and Africa, covering probably 25,000 miles in a year (about twice as much territory as the average United States automobile traverses).

The tagging of mammals and fish often presents some rugged

Harold M. Lambert



Diagonals. The spot — stacking yard of a South Carolina sawmill



F. S. A. photo by Lee

From the photographic wealth of the Farm Security Administration's important record of life in America, The Review has been accorded a varied portfolio. Here are farm tools in an interesting array in Maricopa County, Arizona. Other bits from this portfolio are to appear in the fall.

technical difficulties. Whales and swordfish, for example, do not lend themselves to trapping and must be harpooned with an appropriate identification. Some fish, such as the California herring, are too small to permit external attachment of a marker, and the tag hence must be inserted into the abdominal cavity after an operation. Since the small Pacific herring are used mainly for oil and meal, they are not cleaned individually. The custom has been to recover the tags in the reduction plants by passing the fish meal over a magnetic pulley, but such a method does not permit relation of a tag with an individual fish. An apparatus has therefore been devised which consists essentially of an induction coil through which the fish passes on a conveyer on its way to the reduction plant. The presence of a metal tag within the body of a fish (among 100,000 fish, less than one will be found to have a tag) changes the inductance, and this change, by means of a bridge circuit and an amplifier, activates a thyratron tube which in turn operates a fish-rejection mechanism that throws the unfortunate icthyoid to one side.

Bang Voyage

THE chief danger that now faces a milling machine or a box of dried prunes on its way to England is, of course, an encounter with high explosive, but there is also the not inconsiderable and ever present risk of damage through the routine hazards of ocean transportation. From the time they are placed in the slings by stevedores working under pressure to get the ship away from the dock in the least possible time, to the moment they are deposited, probably with a hearty bang, on the bobbing deck of a lighter, export packages are subjected to far more severe conditions than those ordinarily met in domestic transportation. Aside from the crushing and shock loads during cargo handling, export packages may also be chafed and rocked for weeks while temperatures fluctuate violently and the air is saturated with salt-laden moisture.

An illustration of the kind of treatment that shipping containers are expected to take is indicated by the Bureau of Explosives' test for the carboy, which is a twelve- or thirteen-gallon glass bottle housed in a wooden frame and used to carry corrosive liquids. To be tested, the carboy is placed in a cradle suspended on a 16½-foot pendulum, is filled with water, is pulled outward some fifty-five inches, and then is let crash against a concrete block. This procedure, it is stated, gives the carboy about the same treatment that it would get if riding in a freight car going at four miles an hour and suddenly brought to rest.

The covering of exposed metal parts with oil, grease, or rust-resistant coatings is routine transport procedure, but some use is also being made of absorbent materials like silica gel, which are placed inside packages in order to keep the air in them dry. And, as an acting trade commissioner at Singapore remarks, "Long experience has dictated the wisdom of using tin-lined airtight and moisture proof boxes for all perishable goods which are not individually packed in airtight containers."

In contrast with the domestic field, where fiberboard is probably the most widely used material for shipping containers, wood finds extensive use for ocean-going packages, although fiberboard and plywood are finding increasing application. Domestic containers of plywood may use a three-ply of 3/20-inch thickness or less when an export package would require thicknesses of 3/16 of an inch to 5/16 of an inch or more, and perhaps a five-ply. Nevertheless, ocean transportation can at least display a trial package which almost reaches the ideal of having no weight to carry and no material to discard at the end of the journey: Bales of rubber wrapped merely in rubber sheets have been shipped to the United States, making the journey with apparently satisfactory results.

On the other hand, the export containers for an airplane ordinarily weigh more than the plane they house. Usual practice is to box fuselage and wings separately, the fuselage being fastened to the floor of the wooden case at two of the three points where the plane normally takes stress, i.e., tail and landing gear or tail and wing roots. No other part of the plane touches the box. The statement has been made that, excluding trucking, the packaging of a Brewster fighting plane requires 150 man-hours.

Science and Art

SIEGFRIED GIEDION is one of the foremost contemporary critics and historians of art and architecture; he is a resident of Zurich, Switzerland. Frank Lloyd Wright has been acclaimed abroad as the greatest American architect and one of the important men of all time in his profession; he lives sometimes in Spring Green, Wis. Eric Gill, recently deceased, was a famous English sculptor, graphic artist, craftsman. All three men have written well; recently all three have published books * which throw light of different color on the same general subject.

The subject, one of endless discussion, is the division between thought and feeling, between science and art. Giedion, the most perceptively critical of the men, expresses the question best: ". . . the doubt as to whether science and art have anything in common. The question would not be raised except in a period where thinking and feeling proceed on different levels in opposition to each other. In such a period, people no longer expect a scientific discovery to have any repercussions in the realm of feeling. It seems unnatural for a theory in mathematical physics to meet with an equivalent in the arts. But this is to forget that the two are formulated by men living in the same period, exposed to the same general influences, and moved by similar impulses. Thought and feeling could be entirely separated only by cutting men in two. . . . The degree to which its methods of thinking and of feeling coincide determines the equilibrium of an epoch. When these methods move apart from each other there is no possibility of a culture and a tradition. These are not deliberations remote from our subject: . . . it was just this unfortunate schism between its thought and feeling which struck down the magnificent power of the nineteenth century. Out of such a schism come split personalities and split civilizations."

The three books are all important books, and here we may concern ourselves only with the manner in which they approach this one problem. Gill found the easiest way out. In his early life he was determined to cooperate with science and its child, the machine. The task became too hard, and his retreat — which he defends with vigor and brilliant writing as well as with brilliant accomplishment in the handicrafts — was complete. He simply fought the singlehanded battle against the hands of the machine. His position was at least clear; where it will leave him as an artist for posterity may not be so clear.

Frank Lloyd Wright, on the other hand, has asserted with vigor that the architect must accommodate himself to the machine, that in an artist's limitations lie his greatest opportunities. Yet one detects in his writing a species of self-hypnotism: If ever there was an architect who talked about using the machine while virtually his every act belied the talk, it has been Wright. For the laws of structural or heating engineering he has slight respect. He often places his own intuition above the accumulated knowledge of science. Intuition is not always wrong, and the foregoing remark therefore is less a criticism of a great man than a statement that his work is in contradiction to his teaching and that he, too, has not solved the riddle.

Finally, what would Giedion himself propose? He starts clearly enough: "The problem of today is not to popularize science. What our period needs much more than this is to gain an understanding and a general view of the dominant methods in different fields of human activity, recognizing their differences and their likenesses." He also says, "The methods of science, are of more concern to us now than any of their separate results."

Yet this is nearly as far as he is able to take us. An interest in construction leads him through a brilliant exposition of the development of the steel frame and of the principles of Maillart's bridges (which, by the by, are more appreciated by architects than by engineers). When Giedion must single out architects who seem to him to carry forward in the right direction, he comes back to the great names, such as Berlage, Le Corbusier, Gropius, Aalto. But important as the contributions of each of these men may have been to architecture per se, little application of scientific method

* Giedion, Siegfried. *Space, Time and Architecture.* Cambridge: The Harvard University Press, 1941. Pp. xvi+601. $5.00.

Gutheim, Frederick (editor). *Frank Lloyd Wright on Architecture.* New York: Duell, Sloan and Pearce, Inc., 1941. Pp. xviii+275. $3.50.

Gill, Eric. *Autobiography.* London: Jonathan Cape, Ltd., 1940. Pp. 283. 12*s*. 6*d*.

The nameboard of an Ohio town restates the problem which has engrossed philosophers: How shall we incorporate Utopia?

F. S. A. photo by Rothstein

is visible in their work. There is undoubted admiration for science, a wishful straining toward science, but in the last analysis their most brilliant results (as well as their worst failures) have been obtained through intuition.

Giedion himself fails to note the importance of the panel, as indicated by the brilliant design of the broadcasting studios in Hilversum, Holland, where a full collaboration of architects and engineers brought kudos to all. But the fact probably is that in the present complexity no man can be a full man. The scientist cannot run everything, nor can the artist, nor can the politician. The most that can be asked is that each in his cell try to understand the methods of the other before he complains about the results.

Wedding

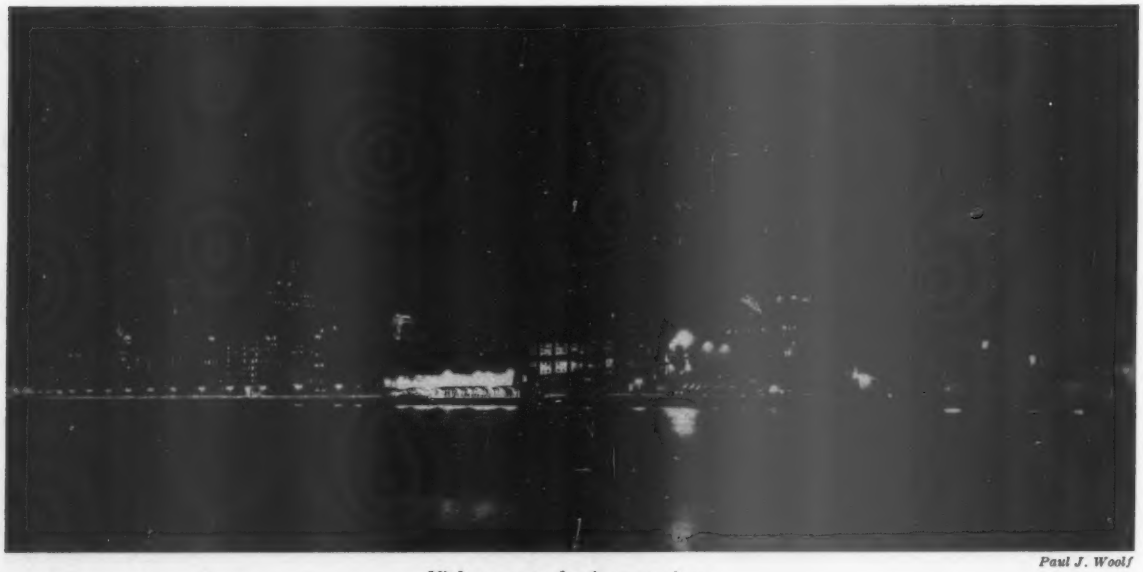
SCIENCE and art have been wedded at the Institute in recent months, as a result of a long period of preparatory study, and the event bids fair to provide sculptors with a medium and a method of using that medium which will overcome several of the chief obstacles to widespread individual possession of the works of their art.

The story of this wedding had its start eight or ten years ago in the inauguration of research into ceramics by Frederick H. Norton, '18, Associate Professor of Ceramics, and continues in the present with the translation of the results of Professor Norton's work into sculptural methodology by George Demetrios, the noted American sculptor, who is at present a guest of the Institute. Mr. Demetrios, a member of the faculty of the Pennsylvania Academy of Fine Arts as well as an artist in his own right, has been busy in the ceramics laboratories of the Institute for some months. The end of this continuing story cannot yet be written, but suggestions of it appear in the recent visits of other sculptors to the Institute and their study of the method.

We could have given this wedding a far earlier start; we could have said that the preliminary conversations about dowry and so on were begun in the Renaissance. Or, wishing to be really emphatic about it, we could have dated the wedding all the way back to Classic Greece and located prognostications of it in the ancient town of Tanagra in Boeotia, famed for a battle in 457 B.C. and more famed for the terra-cotta figurines found first in its graves. These miniature statues, made of baked and painted clay and showing ancient Greek citizens in various poses and activities, supposedly had some ritualistic significance. Found in graves in many parts of the country, they are called by the name of the town where archaeologists first encountered them.

There is thus nothing new about making molds of a piece of sculpture, producing from them a hollow clay replica of the piece, and baking the clay to make it durable. Such terra-cotta work is very ancient. What are new in the recent events at Technology are knowledge of the material, and the power of control which such knowledge brings. These are Professor Norton's contributions. Their significance to sculptors and to those who appreciate sculpture will later appear. For the moment, we are concerned with how Professor Norton, who is by way of being a finished sculptor himself, established the rational basis on which such good results are being built.

One of the great barriers to the use of terra cotta in the fine arts has been the fact that clay when fired will shrink. Shrinkage in itself is not always a serious trouble; unpredictable or nonuniform shrinkage, however, is a very bad thing. The qualities of the clays composing the slip, or fluid mixture, placed in the mold determine how much the product will shrink upon being fired. Hence, knowledge of the properties of different ceramic materials can be utilized in the composition of slips whose shrinkage can be predicted. One such mixture worked out by Professor Norton consists of 25 per cent quartz, 36 per cent feldspar, 18 per cent ball clay, and 21 per cent China clay. (*Continued on page 436*)



Paul J. Woolf

Night comes to the city water front.

No Subtleties to Perplex

This Year's Graduates Face Issues Clearly Drawn, in a World Where the Defense of Human Rights Calls for the Strong, Simple Virtues

By Karl T. Compton

President Compton's address to the Class of 1941 in the Institute's seventy-fourth commencement — direct, thoughtful, and stimulating — is presented verbatim below.

SOME years ago I overheard a discussion of the effect of the motion-picture habit on the characters of young people. A dean of one of our great universities defended the movies on the ground that their portrayal of moral issues is generally so clear cut. The hero is always brave and loyal, the villain is always treacherous and selfish, and virtue is always rewarded. This dean said: "It is a great relief not to have to worry about subtleties which mix you up. The strong, simple virtues are the best."

I am reminded of that point of view as I think of your situation today. As compared with your predecessors who were graduated in the past decade, you face a world where the issues are clearer and the course is better defined. I do *not* mean to imply that your way will be easy, or that you have no problems. That implication would be far from true, for the further we achieve a level above that of the contented cow the more we must face problems, make decisions, and exert ourselves to carry through. What I *do* mean is that the day calls for the "strong, simple virtues," and you need not worry or lose self-confidence over such questions as: "Am I of any use in the world?" "Is the technological career for which I have prepared myself outmoded?"

Ten years ago the depression had upset confidence in the very foundations of our economic structure. We were told that unrestrained enterprise and technological progress had overbuilt production far beyond our capacity to consume the goods produced. We technologists wondered if we had any right to be alive, let alone do our job, as we heard and read the theories of those who argued that higher standards of living are assured by curbing production, not stimulating it; by making production more expensive rather than cheaper; by distributing wealth by laws without much thought of how this wealth can be created. So, ten years ago our graduates faced a world in which few of them seemed to be needed, and in which the tide seemed to be running against them.

Today the contrast is startling. No need in the country is so urgent as that for more and better technically trained men, no objective more important than increased productive power. And the pure scientist is suddenly found to be very useful, as is always so when affairs get away from conventional paths. If some of you who hope to practice architecture have not yet felt such great pressure for your services, don't be discouraged, for, if anything seems certain in this uncertain world, it is that there is going to be a lot of housebuilding the world over when the present international mess is cleared away.

Perhaps it is not pleasant to think that this change in your favor has come because of war. I believe that it was coming *in spite* of the war, and that the present defense activity has only switched into temporary channels and stimulated a movement which was already under way. Witness the scientific research program of the National Association of Manufacturers, now in its third year; and the program of the new-products committee of the New England Council; and the recent rapid increase in the number of industrial research laboratories; and the activities of the National Resources Planning Board of the Federal Government; and the statements of farsighted labor leaders. These are all evidence, independent of the war, that people in important places have reacted against the panicky confusion of ten years ago and that they see in technological progress, in development, and in production, one of the essential elements of national prosperity — a prerequisite to any and all sound schemes for the economic betterment of every social group.

So, without further elaboration, I make the straightforward statement of fact: You are entering a world at a period of urgent demand for people of your professional abilities and training and under circumstances which give reason to hope that this opportunity is not a temporary war phenomenon but is an element of the solid structure of human progress. This fact should give you confidence and courage, two of the "strong, simple virtues."

But more is at stake today than your opportunity to find employment and satisfaction in knowing that your work is worth while. There are at stake over the entire world some of the most important achievements which men have won in their centuries-old struggle to learn how to live as a social group. And scarcely anyone, be he interventionist or isolationist, doubts that these world events include a threat to the institutions and privileges which we in America hold most dear. The only doubt is whether, if Germany wins over Britain, the threat to America will become acute within a few months or within a few years.

In this matter also I believe you of this graduating class to be fortunate, for here again are no subtleties to perplex. Once we really understand the issues, there is little question of our objective, namely, to defeat the

Nazi threat; the only question is of the tactics for best accomplishing this objective.

Here I wish to make one thing clear. We have no quarrel with Germany if she wishes to follow a *Führer*, or glorify the Germanic Aryan race, or teach her youth that only that is valid which enhances the purity and prestige of that race, or enter into advantageous trade agreements with other countries. These are matters of internal policy, and one of our democratic precepts, evolved through generations of hardship and frequent failure, is that each major group should have certain rights of self-determination. We may not approve of some of Germany's internal policies, but we can thank God we don't have to live under them. We may admire, and properly so, the efficiency and the zeal with which the German youth follow their *Führer*. But, as I said, these are internal matters, and the German people as a whole gain or suffer because of the government which they themselves have helped to create and permit to exist.

It was when Germany, through her Nazi leaders but with general support of the German people, undertook to impose her will upon other nations through threat of force and then through invasion, conquest, confiscation, and bloodshed, that her affair became an international moral issue. For if the world has learned any one thing by painful experience, it is that peace cannot be maintained if one nation invades another; conversely, however bitter the arguments between them, nations do not become involved in war unless one attacks the other. So perhaps the most tangible result of the first World War was a rather general acceptance of the conviction, of almost the strength of a religious tenet, that invasion of one country by another must at all costs be avoided. But Germany and her Axis partners have each separately been guilty of invasion for purposes of conquest within the past decade. They are the only nations of the world that have been thus guilty. They are now banded together to protect and enlarge their conquests through further threats and wars.

This again is a very clear-cut issue. There are no subtle considerations involved. There are conflicting factors, it is true, such as are expressed by frequently heard phrases, like, "most Germans outside of Prussia are lovable," "Great Britain has not always been fair and generous," "the Nazi youth movement has bred a race of fine physical specimens filled with enthusiasm," and so on. But these details are utterly insignificant in comparison with the main issue, which is the conflict between two utterly opposing ideologies. So we do not waver in our allegiance; we only wobble a bit in our efforts to be effective in its defense.

But look a little closer. The ideology of the totalitarian state appears as nazism in Germany, as fascism in Italy, as bolshevism in Russia, as control by the military clique in Japan. It is characterized by the dictatorial power of a group ruling over all activities in the country; a dictatorial power which forces the entire nation to work as a unit to carry out the objectives of this ruling group; a dictatorial power which permits no opposition either of rival political factions or even of private individual criticisms; a dictatorial power which ruthlessly maintains its supremacy by political assassination, blood purges, and extensive espionage; a dictatorial power which indoctrinates its youth by elimination of free speech, free inquiry, and free information and substitutes propaganda, censorship, and controlled education designed to promote blind adherence to itself and prevent any questioning of its objectives or procedures. It is a doctrine that considers the individual to have value only as a servant of the state to carry out the purposes of the ruling power.

In our democracy, on the other hand, every citizen not only has the right to express his opinions but has the right to cast his vote and thus exercise his proportionate influence in the determination of the rules for protection and co-operation which are the laws of the land. It is a fundamental principle with us that minorities have privileges and protection, and that facts and truth shall not be suppressed or distorted in order to further policies. We hold that all men are equal before the law, and our goal has always been to open wide the doors of opportunity to all who have the urge to enter.

All of these rights can be summarized by saying that our social structure is liberal in the basic meaning of that word, emphasizing freedom. The totalitarian society is based upon conformity, its purpose being "the preservation and fostering of a community of individuals who are physically and mentally alike." I have often thought that patriotism is a sometimes overworked virtue; but there is no question that, in the present war, the issue is far deeper than patriotic adherence to this or that country; it is adherence to one or the other of these two totally opposing concepts of human rights.

And this mention of human rights leads me to a further thought. We have become so used to life as a free people in our democracy that one of the commonest of all phrases is, "I have a right to . . ." this or that. We speak of the right of free speech, the right to own property, the right to strike, the right to vote, the right to an education, the right to trial by jury, the right of way, and so on, and so on, almost ad infinitum. We have come to accept these rights as matters of course and year by year to invent new ones, like the right to old-age pensions and free hospitalization.

The basic statement of our political rights is in our Declaration of Independence: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed."

Now it took hundreds of thousands of years for mankind to formulate and make effective that immortal statement of human rights under a government. It took bloody wars to secure these rights, and we have had them only 165 years.

The point I want to emphasize is that, however much we believe *theoretically* that we have certain unalienable rights, *practically* we have them in one of only two ways; either we have won these rights, or else we had them given to us by someone else who won them for us. And in either case we do not keep them long if we do not defend and deserve them. We speak glibly of our many rights, because we (*Concluded on page 436*)

A Broader Base for Science

More Widespread Understanding of the Scientific Spirit Is A Safeguard for Civilization

By Anton J. Carlson

THE mysteries of the starry heavens and the urgency of human pain appear to have been among the earliest incentives to man's venture into the realm of science. At any rate, the earliest written records of man's experimental and rational gropings toward understanding are in astronomy and human disease. An engineer may challenge this statement. It is likely that primitive man felled a tree across a stream for a footbridge long before he gave rational attention to the machinery of his body in health and in disease. But such primitive engineering feats are probably on the level with today's monkeys' using any available box or stool to reach a banana.

The men of the later Stone Age had acquired not a little engineering skill, if not engineering science, in the making of tools, in the construction of conveyances for water transport, in the erection of buildings for their leaders and temples to their gods. But these achievements seem to have been a mere flotsam on the current of life. At any rate, these tools and these buildings are now mere fossils. What these ancient engineers knew, and how they acquired their understanding, and why their early science failed to be perpetuated — all of this knowledge is gone with the wind, though the race endures.

The same comments can be made about the greater and more recent achievements in applied science of the ancient Babylonians, Egyptians, and Aztecs. Some men among these peoples must have had a respectable amount of understanding and skill in mechanical engineering, some grasp of the forces of nature. All this knowledge was lost. Nothing but ruins, like the fossils of earlier times, and the mummies of the ancient dead remain to stir the curiosity of the archaeologist. The reason for the total disappearance of understandings of nature and the loss of skills in modifying the environment does not seem to be lack of written records, or the complete destruction or dispersion of the people themselves. We find instances of the same total failure of acquired scientific understandings to survive in more recent times, when written records were made. I may cite one example from ancient Egypt and one from the China of but yesterday.

The Smith papyrus, translated by the Egyptologist, James H. Breasted, is estimated by him to date back some five thousand to seven thousand years before Christ. The original and ancient side of this remarkable script deals with medicine — with injuries of various parts of the body and how to treat them. The description of the symptoms of the injuries, as well as the recommendations for treatment, discloses a remarkable amount of knowledge of human anatomy and human physiology. To be sure, on the reverse side of this papyrus are recipes for quack medical remedies of all sorts, formulas for sorcery, incantation against disease, and so on. But I am concerned here with the original truly scientific medical document. As far as we know now, this early knowledge of anatomy and physiology as applied to human injuries was completely lost. It therefore had apparently no effect on the subsequent development of science and medicine in Greece or in Egypt. We may presume that the knowledge was confined to the few. It was in the ivory tower, with no broad base in the life stream of the people of Egypt.

No surprise should be registered at the medical quackery and the religio-medical superstitions recorded on the reverse side of the Smith papyrus. Possibly this ancient period of relative medical understanding was followed by a longer period of medical dark ages in ancient Egypt. But, even if this was the case, medical superstition and quackery are as tenacious of life as are other customs of the jungle: Witness the persistence and flourishing of similar practices in our own day side by side with the results of three hundred years of medical science, medical research, and scientific medical practice. Indeed, misconceptions, frauds, and quackery may flourish in the realms of medicine for a thousand years because of human hope and human credulity, as is instanced by the taking of powdered tiger bone for heart disease by countless generations in the Orient. The mistaken or fraudulent claim of the chemist that he has synthesized a new compound, or similar baseless claims of the engineer that he has devised a new and sure method of smoke control are, in the nature of things, more quickly deleted from the human scene.

My next example may cause surprise, since some may not be aware that vaccination against smallpox was discovered by the Chinese several hundred years before Jenner and the milkmaid in the then Merry England. The Chinese vaccinated effectively against smallpox by taking the dried pox scale with its attenuated virus from a patient and rubbing this powdered scale on the mucous membrane of the nose or mouth. A mild case of smallpox develops, which gives immunity. In the same way, somehow, they had discovered the efficacy of dried, or powdered, seaweed — or even fresh seaweed — and its iodine against simple goiter. Certainly these discoveries did not spread to any extent even in China, though recorded in the Chinese books on drugs and therapy. The discoveries, really scientific discoveries, remained in the ivory tower and for all practical purposes were lost to the world.

These examples from the past do seem to show that, for the endurance and the effective value of science, a broader base than the ivory tower is indicated. The next question is this: Is such a broad base possible? Is the average man or woman — the common man — capable of understanding, of being conditioned to, the spirit and the method of science? The fact that to date the significant contributions to science, the important new discoveries in science, the great generalizations in science, are the work of the relatively few conspicuous leaders in science, has led to the easily accepted view that the rank and file of mankind are either not able or not sufficiently interested in science to understand and follow its spirit and method.

To my way of thinking, nothing about the scientific method is so abstruse or mystical that it cannot be understood and mastered by every man and woman of average mentality. Conspicuous use of the scientific method in securing new understanding is a different matter. For some time to come, that function, that privilege, will probably be only for the few with sufficient curiosity, ingenuity, and drive to defy all obstacles.

As things seem to me, it is going to be more difficult to condition society to the spirit of science, that is, to absolute truthfulness. The primitive thalamus has as yet too much influence on the conspicuously human part of the brain: the cerebral cortex. Armchair dicta, social and political dogmatism, pretense at knowledge and understanding, call for less work and less worry than does the establishment of facts by adequately controlled experiments and rechecked observations.

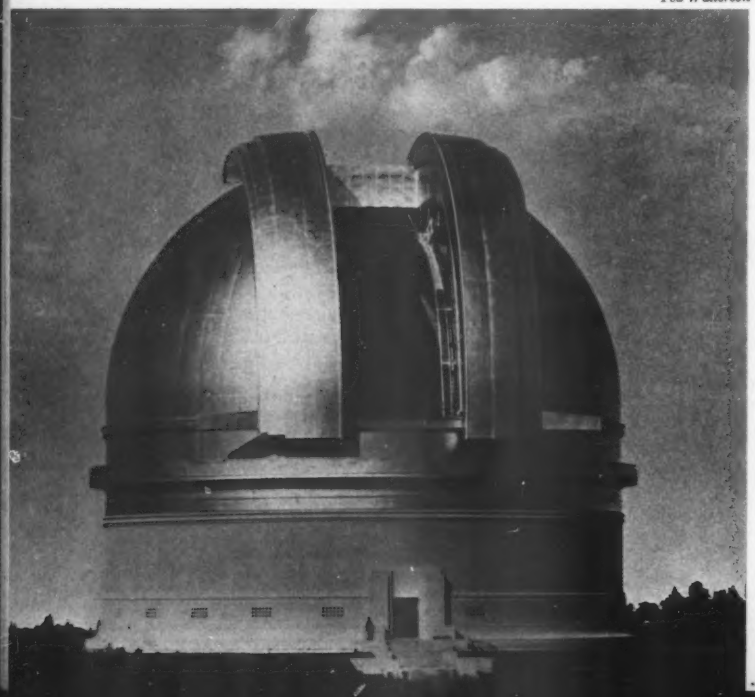
I am a physiologist, not a prophet. According to William James there are, still untapped, "lakelets of energy" in the human brain machinery, ready for more intense, if not more intelligent or better, human behavior. Maybe so, but I doubt it as a universal proposition. We can, however, grasp the scientific method without tapping these hypothetical lakelets. Wherever we go, the *going forward* will not be speedy, judging from the rate of man's evolution. It may be too speedy if the path leads down. As a Roman poet put it long, long ago, "*Facilis descensus Averno*," — easy the road down unto hell. Our esteemed colleagues, the philosophers, have a perennial debate on the question: "Is man a *rational* animal?" Is there, as yet, any evidence of any activity of any man that can be labeled "pure reason"? Strict definition of terms and a small dose of the theory of relativity would in all probability terminate this debate, with the following conclusion: The behavior of the average normal man, including the man of science, is relatively rational in the sense of awareness of facts, motives, and choice, during varying parts of his hours awake. But probably nothing like pure reason (that is, behavior machinery free from conditioning and from affective mental states) is found in any human action.

If our citizens understood the scientific way of establishing facts and the identity of the scientific spirit with honesty and truth, our leaders would not get to first base by promising us complete freedom from want and complete freedom from fear, through any political, social, or economic order. The dreamers of the past put that goal in heaven. It can be approached but never reached on earth by providing freedom to work and to enjoy in full the fruits of one's labor. For it is certain that such calamities in nature as earthquakes, tornadoes, floods, droughts, consuming fires, and killing frosts will create both want and fear among men in the coming years. Some accidents, disease, and pain, some greed, hate, and violence will be with us to the end of time. It is the duty and the privilege of science to decrease the want and fear created by man. It is the duty and the privilege of science to inject understanding, reason, and approximate justice as factors in the social evolution of tomorrow. To do so, I think science must descend from its ivory tower and reach the understanding of the common man.

Since science and scientific research are calling for more and more financial and moral support from society, it would seem to go without saying that in return science owes society the service of education in science so that such support may be given with joy and intelligence. To my way of thinking, a broader base for science in society is urgent and needed: (a) for the persistence and progress of science itself, and (b) for the advancement, safety, and happiness of man. The first point is of no consequence if the second is not true. But obviously if science does contribute to the advancement, safety, and happiness of man, the persistence and progress of science itself become highly desirable. My second proposition is challenged by many people who confuse the primary function of science, which is the increasing of human understanding, with the misuse by stupid man of the practical inventions derived from our increasing scientific knowledge. In the minds of some people, this misuse has reached the state of calling for a moratorium on science for the welfare of man. These people charge science with the following misdemeanors, if not actual major crimes: (1) Science facilitates violence, robbery, and murder. (2) Science promotes and brutalizes war. (3) Science promotes or intensifies unemployment. (4) Science speeds the depletion of some of our natural resources. (5) Science creates or promotes industrial disease of man. (*Continued on page 438*)

On Mount Palomar, this Twentieth Century expression of one of man's first incentives toward science—his desire to learn the mysteries of the skies

Ted Watterson



Individuals and Incentives

Constructive Convictions and Enthusiasm for One's Work Are Essentials for Successful Life

By Robert E. Wilson

THE graduate in science or engineering today understands the forces which make the turbine and the motor operate, or knows how various atoms will react under given conditions, or can predict the behavior of electrons or molecules, given all the forces which act upon them.

Yet he goes out into a world where neither turbines nor motors, atoms nor molecules, are the most important things with which he must deal. If he is really to achieve during his chosen career, he must give a larger share of time during the next decade to recognizing the basic importance of individual persons and trying to understand what makes them act and react as they do, under the various forces and environments to which they are subjected.

Intense concentration on the exact sciences and on the material side of the world's work is bound to make one less attentive to the vital part which individuals play in the world in which we live. The present war must make us conscious, however, that all the achievements of science and engineering may be jeopardized, at least as far as any real benefit to humanity is concerned, by powerful and selfish individuals' misusing them, especially if those individuals can persuade sufficient others to follow. Many of us in business have seen one person in a position of management, or a misguided group of workers, nullify the best efforts of thousands of others and bring a once prosperous establishment to ruin. A business enterprise, large or small, depends very largely on teamwork, and a few unco-operative individuals can demoralize any team. How to get the best out of each individual and work him into a hard-hitting enthusiastic business team is one of the most interesting and important jobs of management.

In the study of individuals and their behavior, as in the study of a new machine, the first question we must ask is, "What makes the wheels go round?" Some of the forces which act on individuals and help to determine their behavior are internal in nature, or what we may term "convictions"; others are external in origin, or "incentives." In the long run, the organization of society which will accomplish the most is that which gives its citizens the convictions and the incentives best adapted to make each individual contribute his best efforts — be they intellectual, manual, or artistic — toward the work of the world.

Consider first the question of convictions: What are some of the constructive and destructive convictions, and what can be done to encourage the constructive ones? Included among the most important are these beliefs: (1) that a real chance to achieve exists, and that success depends mainly on one's own efforts and ability; (2) that there is no substitute for work, and in the long run a life filled with work is more enjoyable than any other existence; (3) that not only is honesty the best policy for the individual but, by and large, American business and business leaders are honest; (4) that the American system of democracy and free enterprise is the best yet devised, even though it is still subject to substantial improvement; (5) that merely making money and achieving power will not give enduring satisfaction unless they are accompanied by abundant and unselfish service to fellow men.

A man armed with these convictions, with enthusiasm, and with reasonable ability is well on the road to success.

Systematic attacks on such beliefs are the worst and most subtle form of sabotage, yet one which is being practiced widely by the enemies in our midst. I cannot imagine a man less likely to succeed, or to be happy, or to be a useful member of society than one who has let himself be led to believe that success depends largely on pull or luck, that most business is crooked, and that our American system is merely an out-of-date folklore.

On the other hand, we cannot expect budding scientists to accept certain beliefs merely because those beliefs, like spinach, are supposed to be good for one. We must be able to convince those scientists that our beliefs are sound.

Let us next consider the external forces, or incentives — the other group of influences which largely determine the actions of individuals. In classifying incentives as external forces, we must not forget that what constitutes an incentive to one man may leave another cold; although incentives may be of external origin, therefore, they still depend to no small extent on the same internal background of attitude and belief which we have been discussing. American companies operating abroad are surprised to find that incentives which appeal to the American worker often fall flat when offered to the native. Even incentives, therefore, must be appraised on the basis of the kind of individuals to whom they are supposed to appeal.

An engineer making an appraisal of the efficiency of the incentives in any given society naturally favors the pragmatic test of success or failure rather than the endless discussions of the theories in the field of political science — if, indeed, this field at its present stage of development can be termed a science. Even the pragmatic test has its pitfalls, however, because we must first define what we mean by success or failure, and then we must be sure that the failure of a given form of society

was due to inherent weaknesses and not to other factors unrelated to its type of organization. We must also remember that temporary success for a few years or even for a generation does not prove that a given form of organization is free from fundamental weaknesses which may sooner or later undermine it.

If we were to judge a society by the magnitude of its advances in thinking and artistic endeavor, the civilizations of ancient Greece and Rome would stand favorable comparison with any subsequent form of government; yet we know that while the wealth and leisure of the few were largely responsible for the desirable results, these results were generally acquired at the expense of slave labor resulting from military conquest and did not yield either material comforts and happiness for the average man or an enduring base for further progress. Strong military powers since that time have played large parts in the spread of what we call civilization and even in the development of science and industry, but again military might and ambition have always seemed to carry the seeds of eventual destruction.

No economic system is an end in itself; rather it is something which has been evolved in an effort to satisfy human wants. I believe there are few persons today who would quarrel with assuming as the principal criterion of success for any form of organization of society the amount of education, leisure time, and material and spiritual comforts which are generally available to the common man. To provide adequate quantities of goods for such a society two principal things are essential: first, the ability and willingness of the great mass of people to work hard to produce the necessary goods; and second, the provision and maintenance of adequate facilities and tools to supplement and magnify the efforts of the individual worker without requiring excessive human effort. Both of these essential elements require the proper incentives to insure their uninterrupted functioning.

Let us consider first the problem of getting continued and intelligent effort from the worker. Many solutions have been tried. Of course as long as each family produced most of its own food, clothing, and shelter, as did primitive man or even our own pioneers, the solution was easy. The relation between effort and reward was so simple and obvious that the maximum productive effort was obtained from almost everyone. The right of any individual to own land in fee simple, so strange and wonderful to those coming from Europe, proved a powerful incentive to pioneer Americans. The meagerness of material comforts which resulted was due primarily to lack of power and tools. Our nearness to those pioneer days and their traditions is to my mind one of the greatest sources of strength of our democracy, and we must never lose sight of the fact that the nearer we can approach that close relationship between effort and reward the better will be our results. Basically, the best incentive is the one most fairly proportioned and directly related to effort and ability.

As more and more division of labor became necessary in order to increase the total productivity of man's efforts, complications entered which have never been entirely solved. Slave labor was one approach, but it went against the deepest sensibilities of the human race and proved to be an inefficient method of getting work done. The fear of punishment has never been even a halfway substitute for the hope of reward, and by the time the overlord or the plantation owner of that time fed his slaves, paid his overseers, and then paid others to oversee the overseers, the poor quality and quantity of work obtained was not particularly cheap.

Republic Steel Corporation

Human nature, enthusiasm — primary elements in the young graduate's problem

The communistic idea in its gentler and more idealistic early forms has been written about for centuries and over a hundred years ago began to appeal to numerous groups in this country. A considerable number of co-operative communities were set up in an effort to get away from the inequalities and frictions which were incident to the division of labor. If this basic idea was ever to succeed, it should have succeeded among some of those groups whose education and ideals were high, and whose wants and needs were simple. In a matter of months or years, however, it always became apparent that the inherently lazy and inefficient were taking too much advantage of their free ride, while those with vigor and ambition were not long content to support the slackers, but either decided to take things easy themselves or drifted away to some place where they felt their ability and energy would receive a more just reward.

Such a process of reverse selection, plus the lack of appeal to the more ambitious younger generation, always brought about the failure of enterprises of these kinds. The present communistic state of Russia is, of course, not truly communistic. It is a dictatorship whose ruling class tries to maintain its power by use of the communistic lingo. Even Russia has found it necessary, in order to make even limited industrial progress, to give special rewards and recognition to the workers of outstanding ability and accomplishment and to allow most of them to own some private property. In many of the farming and some of the industrial regions the drift has been more in the direction of slave labor, with fear of punishment as the main incentive and an all-pervading secret-police system enforcing edicts. No unbiased student of Russia can claim that her few successes can be attributed to true communism, or that the present system is preferable to much of anything except the czarist terrorism which gave birth to the Russian Revolution. Not the true facts of Russia but only the vivid imaginations of some of its paid proponents or parlor-pink followers in this country can have any possible appeal to any substantial group in a nation such as ours.

Another form of highly centralized government is today having a chance to demonstrate whether it is as efficient in the long run as our democratic system. That is the fascist type of organization, where the individual is entirely subordinate to the state, and democracy and free enterprise are despised. Such an organization does have advantages in long-term planning and speedy execution of aggressive action, which no democracy would ever be able to agree upon. As long as the totalitarians can arouse their followers to almost fanatical enthusiasm for their new order as a means of redressing real or imaginary grievances and can maintain a stern secret-police administration to stamp out all evidence of disagreement, such a system will doubtless produce results.

The dictator who is a willing aggressor has a great advantage in modern warfare, also, in being able to make detailed and secret plans for concentrated attacks on a series of secret objectives, while the divided democracies which would oppose those attacks cannot plan effectively to meet them at an unknown time and in an unexpected place, and can keep little, if anything, secret. The Battle of France well illustrated this advantage of a dictatorship and also showed that a nation which is united in believing in something, even if that something is wrong, is far more effective than a nation which is divided and believes in nothing — not even in its own leaders.

A few years, however, cannot tell the story of the success or failure of any new organization of society. Already, in adversity, free democracies appear to become stronger and freemen to fight more zealously, whereas under a dictator adversity gradually leads to disillusionment. Blind obedience to a supposedly all-wise leader does not make the best fighters, especially in the air or under other circumstances when individual enterprise is at a premium. The outstanding achievements of the Royal Air Force against heavy odds during the past year have gone far to justify the confidence and respect which democracy places in the individual.

Using the criterion of the freedom and the material welfare of the common man, there can be no question that our own nation now leads the world by a wide margin. Its 160 years of rapid progress and stable government are a tribute both to the plans of the founding fathers and the honesty and ability of most of their successors. I am sure, however, that I need make no defense of our democratic form of government. The question to which I would address myself is whether the form of organization of business sometimes referred to as our capitalistic system is fundamentally sound and adapted to the modern world.

I think one of the worst things about this form of organization is its customary name, which, together with the usual cartoon of what is supposed to be a capitalist, starts the system off with a heavy handicap in any popular debate. To give it that name is not fair, because "capitalistic" falsely implies that a return on capital is the main purpose or result of the system. "Profit" system is another misnomer applied by enemies, as if profits to capital were guaranteed. I think the most accurate name for our form of organization of business is the "hope-of-profit" system, which, by skillfully holding out to capital a reasonable chance for substantial profit, can get more risks taken and more new industries built than if it guaranteed the small average rate of return which venture capital is able to make over a period of years, after losses are deducted. As far as capital is concerned, the system works a good deal like a lottery or the dangling of a carrot before a tired horse — except that if the business horse is lucky enough to get the carrot, he finds that the tax collector has already sliced off from one-third to one-half.

To my mind the ultimate success of our hope-of-profit system depends upon its ability to maintain fair and reasonable incentives — upon compensating our workers in proportion to their abilities and efforts and keeping the possibility of still greater rewards ever before them. The New Deal deserves credit for increasing the participation of the workers in the output of our industry, especially in industries where wages were particularly depressed. The New Deal must also be commended for its effective action to prevent stock manipulation and other devices which became all too popular during the hectic Twenties. These devices rewarded the speculator and manipulator, at the eventual expense of the real producers, and built up a fundamentally unsound business structure. Much of the recent social security legislation has tended to eliminate weaknesses which had become apparent in our system as industry became more and more important in our national life and as the business cycle hence became more disruptive in its impact on the whole national economy.

On the other hand, some of the tendencies of existing and proposed legislation strike at the very roots of the incentives of all classes of society. The incentive for capital to take risks has been greatly reduced by heavy taxation on both corporations and individuals. The incentive is especially reduced when taxes take the familiar pattern of "heads I win and tails you lose." The incentive for management to produce is reduced by heavy income taxes, arbitrary price limitations, and growing restrictions and (*Concluded on page 438*)

Progress Report

The Accomplishments of Science in Medicine to This Point Are Varied and Important

By Frank H. Lahey

AN ALUMNI DAY CONFERENCE PAPER

USING quite simple terms and trying to cover a very large field very quickly, I should like to mention high spots in developments in medicine and surgery and their relationship to science and engineering. First I should like to say a few words about some of the accomplishments of surgery. A recent outstanding one is the total removal of the stomach. We have forty-two patients with no stomachs, their stomachs having been made for them out of segments of intestines. One patient, who has gone four-and-a-half years with a piece of intestine as a substitute for her stomach, is well, married, and since operation has been able to carry on normal activities. We used to think the appetite came from the contractions of the stomach. This patient has just as good an appetite as you and I have; she likes the smell of bacon and coffee in the morning. Therefore, we can probably assume that the appetite is cerebral in origin.

Although we all feel distressed about the situation in cancer, I am not sure that we should. We have operated on 1,200 patients with cancers of the colon or rectum; 57 per cent of the patients who had carcinoma of the rectum and 43 per cent of those with cancer of the colon are alive and well, with no evidence of recurrence five years after operation. In cancer of the larynx, engineers have played a great part. Think of the people who have their larynges removed and are able, by means of a reed instrument, to talk with the so-called artificial larynx. This is a tube inserted into an opening in the stump of the windpipe after the entire larynx is taken out. The pipe goes into the lip for articulation.

In the body are small substations, like sub power stations, which have to do with temperature in the extremities. The lumbar ganglia in back of the intestines control the nerves which cause the blood vessels to dilate. We know that a child who has had infantile paralysis often has atrophy of the muscles of one leg, so that the leg does not grow so rapidly as the opposite leg. If the ganglia are taken out on one side, the temperature in that leg is thereby elevated, the blood supply to it is increased, and its growth is enhanced. By means of this procedure as much as two inches can be added to the leg.

Now let us turn to the particular things which scientists and engineers have aided. We have been interested in thyroid diseases. Metabolism — the production of energy in the body — is controlled by thyroxine, the active principle of the thyroid gland, which stimulates prolonged energy production. The consumption of oxygen, whether it is above or below normal, is largely related to the activity of the thyroid gland. The test for oxygen consumption is emotionally controlled, and so we have sought for a good many years a test which would not be made abnormal by emotions. Dr. M. A. B. Brazier of England produced one called the impedance angle test, with the idea that saturation of the tissues with thyroxine changed the permeability of tissue, which could be read in terms of the impedance angle, or power factor. Thanks to J. Warren Horton ['14] of M.I.T. and Professor Jamison R. Harrison of Tufts, we have been able to demonstrate that this is not a dependable measurement of thyroid activity. It is of course just as valuable to know that things are not of dependable value as to know that they are.

Next let us consider the matter of hyperthermia. Hyperthermia was made possible by some of the researches of Willis R. Whitney ['90] at the General Electric Company. It was furthered by Charles F. Kettering in developing the use of air conditioning, and also by many others. By this method, temperatures can be elevated to 105 degrees and 106 degrees. A Viennese physician discovered that by producing malaria, with its high temperature, he could destroy the organisms causing syphilis. The spirillum of syphilis is hypersensitive to high temperatures, so that, by means of hyperthermia in general paresis, syphilis germs in the brain can be affected. Gonorrhea, a disease which not only involves the genital organs but also produces stiffness in the knee joint, can be affected by these high temperatures. When subjected to high temperatures, cancer cells become extremely sensitive. Therefore, the suggestion has been made that they be subjected to hyperthermia and, while they are sensitized by hyperthermia and hence are less radioresistant, be irradiated with x-rays.

Another matter of interest, discovered by Professor William H. Howell of Johns Hopkins and made practical by Dr. Charles H. Best of Toronto, is heparin. Certain diseases produce too much clotting of the blood, causing the clots that go to the brain or the lungs and bringing about fatalities. Dr. Best, who on insulin worked with Dr. John J. R. Macleod and Dr. Frederick G. Banting, has recovered heparin from the lungs of cattle and refined it. Now blood can be so heparinized that it will not clot for eight, twelve, or twenty-four hours, an achievement of great value for those patients who, after operation, occasionally discharge clots into the blood stream. When we want to sew blood vessels together, blood clots sometimes catch on the suture line and obstruct the flow. If we heparinize the blood of these patients before sewing the vessels together, the blood will not clot at the line of suture.

The advances in anesthesia are interesting. People can now be put to sleep by injection of one drug and immediately wakened by another: Pentothal can be introduced intravenously, and before the patient can count to twelve he is sound asleep. If picrotoxin is introduced, it will waken him, and he can then be put back to sleep.

The hydrocarbon anesthetics are interesting. People who are being operated upon must have plenty of oxygen in the anesthetic mixture. Nitrous oxide, laughing gas, has 9 per cent oxygen in an anesthetic mixture; ethylene (C_2H_4), the first hydrocarbon employed for anesthesia, has 15 per cent oxygen; but cyclopropane (C_3H_6) has 85 per cent. That is a great development, particularly for those people who are quite ill and who seriously need to have oxygen. However, cyclopropane has the disadvantage of explosiveness, to control which we turned to the M.I.T.

The Institute and other similar scientific centers have been interested in the cyclotron, which has also been of assistance to the medical profession. By means of the cyclotron, iodine can be irradiated and thus the absorption of iodine by the thyroid gland can be followed. Likewise, the cyclotron has aided treatment of leukemia, which amounts to a malignant disease of the blood. Until recent years nothing really could be done for patients with this disease except irradiating certain parts of the body. It is now possible to irradiate phosphorus, to introduce it into the blood stream, and thus to disseminate irradiation throughout the blood stream. To be sure, progress with this method of treatment is still in its infancy and no one can make any promises, but it at least offers a new development.

We all think of helium as something to be put into dirigibles; however, it is also used in anesthesia. Helium is metabolically inert; you and I can breathe it with no effect. As you know, the molecular speed of a gas is in inverse proportion to its molecular weight. The molecular weight of helium is 4, as compared with a molecular weight of 32 for oxygen. Thus, helium can be used to dilute oxygen. If a patient has a narrow windpipe from a goiter pressing upon it, he can with difficulty be supplied with an adequate amount of oxygen. Oxygen, which is a heavy gas, can be diluted with helium. If 80 per cent helium and 20 per cent oxygen are mixed, three times as much oxygen can be got through a given aperture as if pure oxygen is used, because of the fact that helium is such a light gas. Helium is also of great value in treating asthma.

Some of the outstanding developments in medicine come under the heading of chemotherapy. The sulphonyl group — sulfanilamide, sulfapyridine, sulfathiazole, and sulfanilyl guanidine — have one very desirable factor, specificity for separate germs. Sulfathiazole, for example, attacks the staphylococcus and the germ causing pneumonia. Sulfanilyl guanidine, a new drug, is specific for the colon bacillus which inhabits the intestinal tract. Fortunately, sulfanilyl guanidine is a water-soluble chemical but is absorbed slowly from the intestinal tract, so that high concentrations can be obtained in the intestinal tract. Surgical operations hence can be made safer by preliminary administration of sulfanilyl guanidine.

It is well recognized now that we must be careful in our use of these drugs. They do not kill organisms; they inhibit the growth of organisms and thus permit the natural defense mechanism of the body to destroy the organisms. We must be careful because, while these drugs are useful, they have depressing effects upon liver function and kidney function, and materially diminish blood counts. For this reason one should not speak about chemotherapy without warning everyone of the dangers in the employment of these drugs without supervision by a physician.

Everyone, of course, is interested in the vitamins. We have learned much about them. In the Lahey Clinic, where we have operated on more than 20,000 goiters, we naturally have seen many things in relation to goiter. Very often, clinical impressions foreshadow scientific discoveries. We have known that the people who have goiters have night blindness, i.e., they cannot see well in the dark. We never knew why, but we knew the condition was associated with thyroid diseases. Now we know why — vitamin A deficiency. What has that to do with night blindness? In the back of the retina is a material called visual purple, by means of which people see in darkness. When vitamin A is low, the amount of visual purple is diminished, so that a person cannot see well in the dark. The amount of vitamin A can actually be determined by photometric measurement of visual purple.

One of the most fascinating of all the vitamin developments is vitamin K, which is found in alfalfa, in greens, and, of all places, in rotten fish meal. We have known for a long time that the cause of jaundice is bile backing up in the blood stream. Patients who are deeply jaundiced bleed when they are operated on; they have lost a factor which produces clotting. Now we know that the factor is vitamin K. When it is given with bile, in which it is soluble, it has the ability to be taken up by the liver, where it is synthesized into the material called prothrombin, the factor which is lacking in jaundice and the presence of which restores the ability of the blood to clot. The great difficulty with vitamin K is that if patients are going to bleed, they cannot be given bile and vitamin K, for they cannot absorb it quickly enough. It has now been synthesized and has the name 2-methyl-1,4-naphthoquinone. This material can be given intravenously, and in three hours blood which would not clot can be made to clot.

The active principle of glands is of importance. One of the most interesting is the active principle of the adrenal gland, located over the top of each kidney. The two adrenal glands control blood pressure. We know that they occasionally are attacked by tuberculosis and that if they are destroyed, a fatality results from a condition called Addison's disease. Previously nothing could be done for patients in this condition. Now, Professor Wilbur W. Swingle and others at Princeton have demonstrated that they can produce the active principle of the adrenal gland, which is called desoxycorticosterone. This material can be sterilized, put into a tube, and pounded into a hard pellet which, if introduced under the skin, will be absorbed slowly. I have introduced several of them myself. A little slit is made under the (*Concluded on page 457*)

Arming the Physician

Vast Applications in Medicine Are Found for Devices Which Physicists Have Developed

By George R. Harrison

AN ALUMNI DAY CONFERENCE PAPER

ALL men are made of atoms. However, since more than atoms are needed to make a man, we do not entrust the entire care of our health to physicists. The atoms in our bodies are arranged in cells; so we need biologists. And the cells are grouped together into tissues and organs; so we need physicians. It is, nevertheless, no mere accident that the words "physicist" and "physician" differ in only two letters out of nine.

The modern physician is well armed with mental tools by the psychologist, with liquid tools by the chemist, and with solid tools by the physicist. Mental and liquid tools serve primarily for cure. For diagnosis the physician has always relied heavily on the physicist's devices. Who makes more temperature measurements in the course of a day, or more determinations of hydrostatic (or is it haemostatic?) pressure, than does the family doctor?

In recent years — one might almost say in recent months — many of the new devices which the physicist has developed have found vast application in the field of medicine. For this result the physicist deserves little credit, perhaps, inasmuch as he usually has made his contribution not deliberately but on the run while in the pursuit of his all-absorbing problem, the ultimate structure of matter. To his most exciting contributions to medicine — the microscope, of which 50,000 are in use in this country; and the x-ray machine, of which 25,000 are in use — the physicist has now added many more. I shall confine my discussion to three typical advances: the electron microscope, the spectrograph, and devices for the production of subatomic rays.

The sharpest-visioned medical man cannot, with his unaided eye, see any detail on bug or bacterium which is less than 1/125 of an inch long. In other words, the limit of resolution of the eye is about .008 inch; two points closer together than this look as one. The fault lies in the eye itself. Through selective breeding we might be able to grow a race of men with saucerlike eyes containing duplex lenses, but for immediate purposes we had better call in the physicist. He responded first with the magnifying glass. By use of this simple lens to magnify an object, say, five diameters, the two previously closest separable points become 1/25 of an inch apart and are much more comfortably scrutinized.

Next came the compound microscope, essentially two lenses placed one behind the other, giving an over-all magnification of two thousand diameters and thus enabling the physician to separate visually two points as close together as a few millionths of an inch. With the compound microscope at its highest degree of development, hundreds of varieties of bacteria became visible. Was the physician satisfied? By no means, for even then numerous viruses were too small to be seen, and many interesting creatures were merely tiny blobs on which no detail whatever was visible. This circumstance led to a long and difficult period of attempted improvement in the microscope, during which progress was slow and slight. Physicists knew why. The trouble was not so much in the microscope as in the light waves which traversed it. The waves were too long.

The light waves which are used in microscopes are themselves about sixteen-millionths of an inch long; therefore it is hopeless to attempt to separate with them two points which are closer than about four-millionths of an inch. With visible light waves, then, the limit of effective magnification is about two thousand diameters; any greater factor must be thought of as being for convenience rather than as giving further essential information.

But the physicist has discovered many other kinds of waves. Ultraviolet light has long been known, and its waves range all the way down to the x-rays, which are about 1/4,000 as long as waves of light. An x-ray microscope is out at the start, however, for no one has yet learned how to bend an x-ray so as to focus it into an image. X-rays can be scattered by atoms and piled up so that they give useful information, but this is not the equivalent of direct vision.

Until we reach waves about half as long as those of green light, we do not find them at all easy to handle. For such waves it has been possible to develop a special

These pictures show successive stages in the assembly of the latest in the group of machines built at Technology to utilize for medical and industrial purposes the technique of constant-potential generation put to work by Robert J. Van de Graaff, Associate Professor of Physics at the Institute. In this machine three generators, unaware of each other electrically speaking, are placed one inside the other and collaborate to produce x-radiation with energies over three million volts.

ultraviolet microscope which gives useful magnifications up to four thousand diameters, separating points that are two-millionths of an inch apart. This advance, bought at the expense of long years of hard labor, is still an advance by a factor of only two.

Now comes the electron microscope with its useful magnifications up to fifty thousand diameters and its ability to resolve two points 1/10,000,000 of an inch apart — a gain of fortyfold over the visual microscope! This gain came as a side issue to the development of the quantum theory and the wave mechanics. The first compound microscope designed to operate with electrons instead of with light waves was built in 1932 by M. Knoll and E. Ruska, and during the intervening years the instrument has been improved by various investigators until now, in the hands of V. K. Zworykin and his collaborators at the RCA Manufacturing Company, it has reached a remarkable stage of simplicity, compactness, and ease of use. Yet to suppose that the ultimate form of the electron microscope has been attained or even envisaged would be very shortsighted.

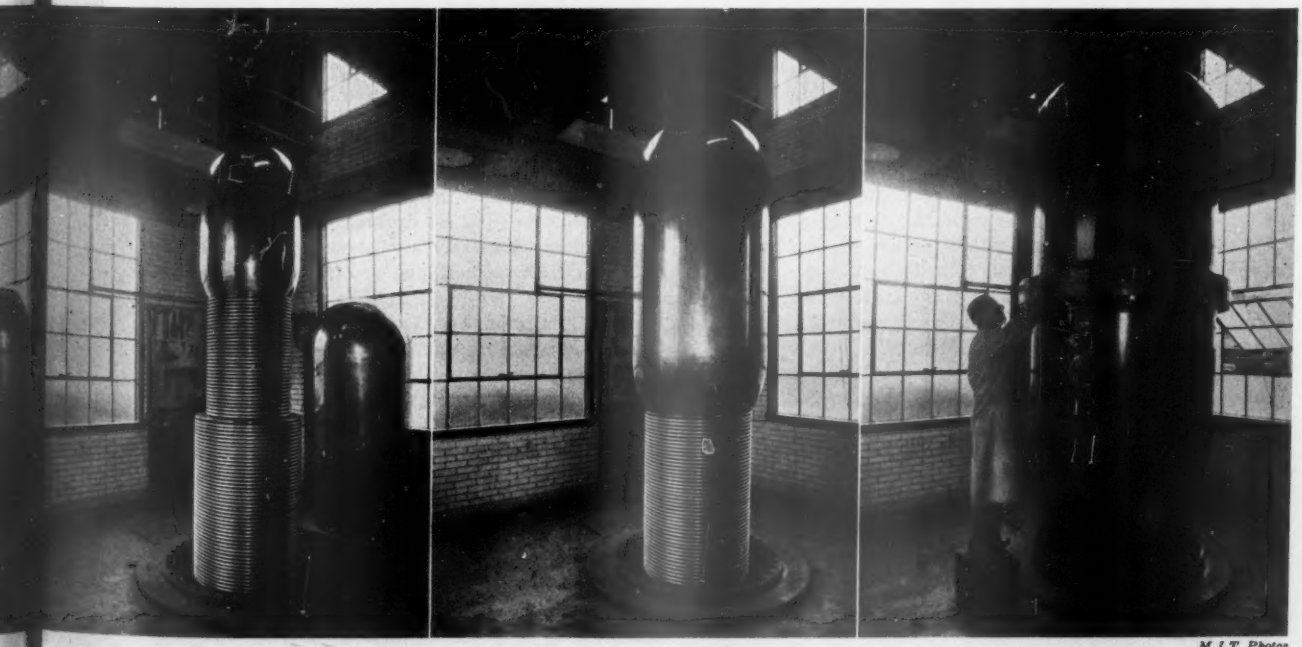
The lengths of electron waves are given by the formula $\lambda = \sqrt{\frac{150}{V}}$, where V is the voltage through which the electrons have fallen and λ is the length of the waves in units called angstroms, which are about four-billionths of an inch. Thus an electron which has fallen through 60,000 volts in a vacuum tube (an entirely moderate value) will have waves 1/100,000 as long as the average light wave and hence might conceivably be used to give one hundred thousand times as much useful magnification. If shorter electron waves are required, one need merely raise the voltage on the vacuum tube in which the electrons are being accelerated. Hence the limitation in useful magnification is now set not by the waves but by the instrument.

In some ways an electron microscope is simpler than an ordinary microscope; yet in other ways it is far more complicated. Instead of a source of light, a source of electrons is used — a hot tungsten wire coated with salts out of which electrons are sweated in clouds into a vacuum. In the vacuum the electrons fall prey to strong electrical forces which hurl them at ever increasing speed in a concentrated beam against the object being examined. In passing through some spots in this object (spots which would appear dark in an ordinary photograph), the electrons are scattered more than they are in passing through other spots and so are lost from the beam. After the electrons traverse the object, they are focused into an enlarged image by coils or electrical plates corresponding to the two lenses in an ordinary microscope. This image is formed on a fluorescent screen, with the result that bright light is emitted wherever many electrons strike, while regions from which the electrons have been scattered appear dark. Thus the electron image is changed into an optical image. Alternatively, a photographic film can replace the fluorescent screen; since electrons register on a film quite as well as light waves do, and in the same manner, the usual type of picture will be obtained.

Electrons, as contrasted with light waves, have difficulty in penetrating air, and so the entire microscope — the most compact models are seven feet high — must be kept pumped to a high degree of vacuum. That this feat can now be accomplished with a minimum of inconvenience, and so rapidly that only sixty seconds are required to load the camera and take a new picture, is a tribute to the engineering skill of the RCA designers.

An outstanding problem in the new microscope arises from the fact that since electrons will not go through glass, ordinary microscope slides cannot be used. To find material transparent to electrons is much more difficult than to find material transparent to light. At present, objects being examined with an electron microscope are suspended on a wire mesh or are placed in water on an extremely thin film of cellulose material through which the electrons can penetrate. Living material can be kept enclosed in a thin vacuum-tight cage of cellulose material which is transparent to electrons.

With the present electron microscope, points as close together as 1/10,000,000 of an inch can be separated and made visible. The instrument as now designed has a theoretical limitation which should enable it to separate points 4/100,000,000 of an inch (*Continued on page 444*)



M.I.T. Photos

Union for Understanding

As the Interrelations of Biology and Physics Are Made Clearer, Means Develop for a Better Social Order

By Detlev W. Bronk

AN ALUMNI DAY CONFERENCE PAPER

IT is gratifying to one who has devoted much of his life to the development of closer relations between the physical and the biological sciences to be present on an occasion which recognizes the importance of the integration of these fields of knowledge. This is a timely period for such an undertaking. The joined efforts of the physicist and the biologist should make possible unique contributions to the solution of important problems for human welfare which crowd in upon us during these days of social readjustment. The relationship is mutually beneficial: The broader human objectives of physics and engineering will be more fully achieved if scientists in those fields are in close touch with the progress of biology. Future progress in biology depends, in turn, on the biologist's wider use of physical tools and principles.

The expanding frontiers of modern science and the multiplication of experimental methods so evident throughout the laboratories of the M.I.T. have required and encouraged severe specialization. Such specialization has been justified by its accomplishments, for without it a worker would be hampered by superficial and inadequate understanding of the problems he is investigating. A synthesis of the sciences, however, is necessary if they are to retain their broader cultural values, for only thus can the detailed facts be seen in their true perspective as parts of a more complete pattern of knowledge. The time has come when the development of science requires individuals and institutions devoted to the correlation of its subdivisions. It is therefore of unique importance that this great center of teaching and research should devote itself to the integration of the physical and medical sciences. Having been at one time or another an engineer, a physicist, a zoologist, and a physiologist, I sense the significance of Technology's undertaking.

The biologist and physician are primarily concerned with two fundamental problems: the nature of the structure of living systems and the modifications which are induced in that structure by changes in the environment. These are the classical problems of form and behavior. Except in so far as they are superficially descriptive, they are merely special domains of physics and chemistry. Their advance has waited in the past upon the development of new tools and new points of view in the physical sciences. The future opportunities of the physical sciences in medicine will necessarily depend upon the future course which is taken by medicine itself.

What that course may be is a hazardous guess. Judging by present trends, I see three lines of development significant to the present discussion. First is the increased necessity for describing the structure and activity of living organisms in terms of fundamental physicochemical processes. This is no new development, but it is being hastened by the disappearing frontiers of classical descriptive medicine and biology and by the stimulus of extraordinary progress in the physical sciences.

Second is the increasing awareness of the sensitive reaction of a living organism to its environment. As our knowledge of the fundamental nature of vital processes is extended, this awareness grows. It is made more acute by the swift extension of physics and the consequently accelerated change of industrial and cultural life. The medical sciences are therefore being led to a keener concern regarding the influence of environmental conditions on the health and habits of man. The growing interests in public health, industrial hygiene, and psychiatry are indications of this second important trend.

Finally, I believe that the dramatic swiftness of the changes in modern life will awaken the physician to the important role he can play in shaping the new order. Civilizations are built by man for man, and a knowledge of the requirements and limitations of human life is essential to the effective direction of social and industrial evolution.

The biologist and physician can make their contributions to the broader reaches of human life only through their understanding of the basic phenomena of living organisms. The analysis of these phenomena will depend, in an increasing degree, upon the use of physical concepts and methods because the living cell, of which all organisms are composed, is an aggregate of molecules and ions subject to no laws unique to living matter. Only in the formidable complexity of their organized structure do cells and assemblages of cells present special problems. Even these problems of structure depend for their ultimate solution upon physicochemical analyses.

As Karl Darrow in *The Renaissance of Physics* says: "When a biologist wants to know the structure of an organism, he proceeds to dissect it. When a physicist wants to know the structure of those simplest of all organisms which we call 'atoms,' he too must dissect it. I do not wish, of course, to suggest that he can take his knife and hack the atom to pieces. . . . No: when I speak of dissecting atoms or dissecting matter, I refer

to the fact that we can draw negative electricity out of every substance which there is. When we pull or drive electrons out of a piece of matter, we are taking matter apart — and taking a thing apart is the traditional way of finding out how it is put together."

Actually, the biologist and physician are beginning to use methods for "dissection" similar to those employed by the physicist. For they now recognize that no matter how delicate may be their knife or how extraordinary their skill, they cannot hope to extend very far their knowledge of the structure of living things by hacking them to pieces. Nor does the microscope give all the information desired. Hence the biologist and the physician look hopefully toward the new tools of analysis developed by the physicist.

It is difficult to overemphasize the importance to biology and medicine of this analysis of the finer structure of living matter, for the arrangement of molecules and ions within cells ultimately determines the characteristics of cellular action. Certain modifications of the structure constitute disease. The measurement of those variations which are hidden from the microscopist should accordingly help to reveal the causes of disease and suggest means for its cure.

The use of x-rays and polarized light has already revealed to Professor Francis O. Schmitt many facts concerning the arrangement of molecules and atoms in cells, and the electron microscope will probably be a valuable asset in his studies. Following the techniques developed by Irving Langmuir for the study of molecular films, Leslie Chambers has shown that the orientation of molecules in the surface layers of cells is an important factor determining the specificity of certain immunological and serological reactions. The brilliant work of W. M. Stanley on the crystalline structure of viruses "has provided reasons for considering that life as we know it owes its existence to a specific state of matter and that the principle of the vital phenomenon does not come into existence suddenly, but is inherent in all matter."

One serious limitation of many methods for observing cellular organization is that they can reveal the living system only as a static structure. Actually, that system is in a continuous state of restless change throughout life. To detect those changes requires, in many instances, the utmost speed and sensitivity available in modern physical methods.

The continual redistribution and re-arrangement of the atomic and ionic components of cells is a consequence of the unique sensitivity of living cells to changes in the environment. This sensitivity is due to the fact that the organization of a cell is unstable. The existence of the complex structure of these organized systems of molecules and ions is maintained only by an adequate supply of energy and depends upon a delicate balance between opposing forces and reactions. It is accordingly not surprising to find that the structure of a cell at any instant is determined by the physical and chemical agents surrounding it. Such a modification of cellular structure by the environment is the physical basis of life.

That is to say, life is the continued sequence of changes induced in cells by previous changes in their environment. If this sensitive reaction to the environment is the result of an unstable organization of the molecules and ions of which an organism is composed, we may well ask whether variations in the surroundings will not modify the organization to such a degree that it will no longer retain the properties characteristic of a living system. In an unchanging environment this outcome is averted by a balance between the forces tending to produce disintegration and those which restore the normal structure. But as the environmental changes proceed, this delicate balance is destroyed and the system tends to disintegrate. That such dissolution is not general is due to the fact that a change in the surroundings not only induces changes in the structure of the organism but induces such changes as will limit the sequence of events leading to destruction of the living state. The only requirement for continued existence as a living system is that the previous properties of the organism shall have become so altered that the new structure can react and adapt itself to a further change of the environment. If the physical surroundings change too rapidly or too much, a new balance between the processes of dissolution and reorganization may not be established, and then disintegration of the living structure will follow.

Remarkable mechanisms have been evolved in the more complex organisms in order to maintain relative constancy of the physical and chemical conditions within the body despite wide fluctuations of the environment. In all of these regulatory mechanisms the nervous system plays a major role, for it is primarily responsible for bringing the vast assemblage of cells into an ordered pattern of activity. A brief consideration of the action of the nervous system will illustrate the dynamic nature of biological systems and emphasize the growing dependence of physiological research on the physical sciences.

We have had clear and detailed microscopic pictures of the outlines of the cells which compose the nervous system and of the differentiated portions which react differently to specific chemical dyes. Such studies, made possible by a physical instrument, have given us a vast amount of important information regarding the arrangement of nerve cells relative to one another. Chemical analyses of isolated nerves have told us of their molecular composition. The intimate nature of the structure involved in the action of nerves and the events that give them their power of control are, however, still problems on the frontiers of biology.

Professor Schmitt has led one important line of progress. By the use of x-rays and polarized light he has made careful and important determinations of the arrangement of proteins and lipoids in the cell surface and has measured the dimensions of membranes. Another attack on the nature of the surface and its changes has been made by Kenneth S. Cole, who has confirmed the theory that a nerve cell controls some remote structure or another nerve cell by the propagation of a wave of electrochemical change which involves a progressive and reversible change of the ionic permeability of the nerve surface. After long years of physical and biological research, Cole has developed methods for measuring the impedance of the surface membranes. He finds that with the spread of an impulse (*Continued on page 452*)

Science and Engineering in Medicine

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THE *eventful progress in physical science made during the present century has its counterpart among the sciences which have to do with the visible and invisible world of living things, leading, not only to the overturning of concepts once thought to have been enduringly established, but also to the development of entirely new divisions of biological science.*" — FRANK F. BUNKER in *Cooperation in Research* (see below).

I. FOR THE GENERAL READER

CARNEGIE INSTITUTION OF WASHINGTON. *Cooperation in Research.* Washington, D. C.: Carnegie Institution of Washington, 1938. Pp. ix+782. $5.00.
Has an entire section devoted to the biological sciences.

HARRISON, GEORGE R., staff. *Atoms in Action: the World of Creative Physics.* New York: Morrow, 1939. Pp. x+370. $3.50.

RATCLIFF, J. D., '25. *Modern Miracle Men.* New York: Dodd, Mead, 1939. Pp. 311. $3.00.
In breezy, journalistic style the first fourteen chapters describe recent developments in medicine.

SHRYOCK, RICHARD H. *The Development of Modern Medicine: an Interpretation of the Social and Scientific Factors Involved.* Philadelphia: University of Pennsylvania Press, 1936. Pp. xiv+442. $4.00.

SMITH, GEDDES. *Plague on Us.* New York: Commonwealth Fund, 1941. Pp. 365. $3.00.

SOLOMON, ARTHUR K. *Why Smash Atoms?* Cambridge: Harvard University Press, 1940. Pp. xii+174. $2.50.

ZINSSER, HANS. *As I Remember Him: the Biography of R. S.* Boston: Little, Brown, 1940. Pp. ix+443. $2.75.
Reflections on life, education, politics, and scientific research by a distinguished bacteriologist and stimulating teacher.

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BUNKER, JOHN W. M., staff. "Biological Engineering," *School Science and Mathematics,* 39:671–677 (October, 1939).

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II. PHYSICS AND MEDICINE

CLARK, GEORGE L. *Applied X-Rays* (3d ed.). New York: McGraw-Hill, 1940. Pp. xvii+674. $6.00.
"Since 1932 [when the second edition of this book appeared], there has come into clearer relief a classification of applications of astounding scope — physics, electrical engineering, spectroscopy and atomic structure, chemical analysis, medical, industrial and artistic diagnosis, photochemistry, genetics, biological identification, cancer therapy, crystallography, crystal chemistry, and ultimate fine-structure analysis of the inorganic and living world. . . ." — Preface.

DUGGAR, BENJAMIN M. (editor). *Biological Effects of Radiation: Mechanism and Measurement of Radiation, Applications in Biology, Photochemical Reactions, Effects of Radiant Energy on Organisms and Organic Products.* 2 vols. New York: McGraw-Hill, 1936. $12.00.

ELLINGER, FRIEDRICH. *The Biologic Fundamentals of Radiation Therapy: a Textbook.* English translation by Reuben Gross. New York: Nordeman (distributors), 1941. Pp. xvi+360. $6.00.
"A comprehensive survey of the enormous mass of scattered information pertaining to the biologic fundamentals of radiation therapy." — Maurice Lenz in the preface. Bibliography of 1,100 items.

ELLIS, CARLETON, '00, and ALFRED A. WELLS. *The Chemical Action of Ultraviolet Rays* (revised and enlarged edition by F. F. Heyroth). New York: Reinhold, 1941. Pp. 961. $12.00.

MANN, W. B. *The Cyclotron.* Brooklyn: Chemical Publishing Company, Inc., 1940. Pp. xi+92. $1.50.

MILLER, ELMER S. *Quantitative Biological Spectroscopy.* Minneapolis: Burgess Publishing Company, 1939. Pp. 213. $3.50.
". . . To give a brief survey of the various types of spectroscopic apparatus available, and to acquaint the student with the details of calibration necessary to give the desired accuracy." — Preface.

ROBERTSON, JOHN K. *Radiology Physics: an Introductory Course for Medical or Premedical Students and for All Radiologists.* New York: Van Nostrand, 1941. Pp. 270. $3.50.

WEYL, CHARLES; S. REID WARREN, JR.; and DALLETT B. O'NEILL. *Radiologic Physics.* Springfield, Ill.: Charles C. Thomas, 1941. Pp. xvii+459. $5.50.
Part I deals with the theory and practice of electrical engineering as applied to radiological apparatus; part II, with the theory and application of radiation physics with reference to x-ray diagnosis and x-ray and gamma-ray therapy.

Articles

EVANS, ROBLEY D., staff. "Applied Nuclear Physics," *Journal of Applied Physics,* 12:260–269 (April, 1941).
The entire issue of the journal is devoted to the applications of nuclear physics and includes abstracts of the papers given at the Conference on Applied Nuclear Physics held at M.I.T. last fall.

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Includes a bibliography of 1,203 references.

SMITH, T. A. "The Electron Microscope," *Scientific Monthly,* 52:337–341 (April, 1941).

TRUMP, JOHN G., '33, staff; ROBERT J. VAN DE GRAAFF, staff; and ROBERT W. CLOUD, '37, staff. "Compact, Supervoltage, Roentgen-Ray Generator Using a Pressure-Insulated Electrostatic High Voltage Source," *American Journal of Roentgenology and Radium Therapy,* 44:610–614 (October, 1940).

III. CHEMISTRY AND MEDICINE

ABRAMSON, HAROLD A. *Electrokinetic Phenomena and Their Application to Biology and Medicine* (American Chemical Society Monograph No. 66). New York: Chemical Catalog Company, 1934. Pp. 331. $7.50.
"Indispensable to every colloid chemist, and especially to those interested in surface reactions in biological and medical problems." — H. B. Weiser in *Industrial and Engineering Chemistry,* July 20, 1934.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SECTION ON CHEMISTRY. *Recent Advances in Surface Chemistry and Chemical Physics* (edited by F. R. Moulton). Lancaster, Pa.: Published for the A.A.A.S. by the Science Press, 1939. Pp. 133. $2.50.

AMERICAN MEDICAL ASSOCIATION. *The Vitamins.* Chicago: American Medical Association, 1939. Pp. 637. $1.50.
These thirty-one articles, which comprise a symposium arranged under the auspices of the council on (*Continued on page 456*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Expression of Technology

Alumni Day 1941 Superlative in Its Statement of All Aspects of the Life of the Institute

TECHNOLOGY in the full strength of its three great characteristics was given superlative expression in the festivities of Alumni Day 1941. The historic tradition and friendly good-fellowship which are the heart of the school, the devotion and contribution to science and engineering which are its identifying activity, and the direct participation in national service which is its function — all were set forth in act and spirit as Institute people gathered again in the annual custom. The efforts of the committees under the general chairmanship of Richard Whiting, '26, resulted in eminent success in the operation of a crowded program; the skies were benign; the high marks set in the past were given yet another boost. Attempting here to survey the whole affair, The Review faces an embarrassment of riches, and hence presents aspects only.

. . . *National Usefulness* . . .

This year, of course, the Institute as a factor in the national life of the country has particular significance. High point of the traditional dinner concluding the day's events was the portion of President Compton's report to Alumni devoted to consideration of Technology's part in national defense. Dr. Compton said:

George H. Davis Studio

The portrait of President Compton unveiled on Alumni Day

The great events in Technology history which we celebrate in this alumni festival of 1941 inevitably emphasize a striking similarity in the years 1861, 1916, and 1941 — all periods of crisis. Eighty years ago M.I.T. received its charter from the Massachusetts General Court as the country plunged into the Civil War. Twenty-five years ago, when the Institute was

M.I.T. Photos

Alumni Day chairman Richard Whiting, '26, preceding scenes of the day. — On the way to luncheon. — The 50-year class table. — C. Frank Allen, '72.

establishing itself in its "more ample home" in Cambridge, we were in another great crisis and on the verge of conflict. And now in 1941, events have come full circle again, and we meet amid the mobilization and fateful challenge of a grim national emergency.

I recall these parallels because they serve to point up our situation today. Looking backward serves to show not only how far we have come but how far we can go despite wars or rumors of wars. Looking backward also serves to surround with the proper humility our pride in the accomplishments of today. . . .

With full consciousness of our indebtedness to the past, I turn to a report on Technology in 1941. . . . The record, it seems to me, reveals a measure of public service and an adaptation to changing needs which fulfill the promises of the past and set in bold relief the vital importance of the Institute as a great national resource.

The first way in which the Institute responded to the national emergency was to provide experts from its staff to serve on various advisory or operating committees of the government. The extent of this service is indicated by the fact that nearly one hundred members of our staff are now engaged in governmental work. The range of services is shown by some typical activities: Robert G. Caldwell, our Dean of Humanities, is associated with Nelson A. Rockefeller in an important program of cultural relations with the South American republics. Edward L. Moreland, '07, our Dean of Engineering, is administrator for northern New England in the National Defense Training Program and serves on a regional committee of the Office of Production Management. Jerome C. Hunsaker, '12, Head of the Departments of Aeronautical and Mechanical Engineering, is a member of the National Advisory Committee for Aeronautics and a special adviser in many government activities. Douglass V. Brown, Associate Professor of Industrial Relations, is serving as a business specialist. And Professor Ralph D. Bennett of the Department of Electrical Engineering, and Francis Bitter, Associate Professor of the Physics of Metals, have been called to important technical service with the Navy. A large group of members of the staff, including myself, are serving on the National Defense Research Committee and its subcommittees. Incidentally, M.I.T. Alumni are well represented on this defense committee. Vannevar Bush, '16, our former Vice-President and Dean of Engineering, is chairman; Frank B. Jewett, '03, and Richard C. Tolman, '03, are members.

The second major defense activity of the Institute is the operation of intensive defense training courses. Last autumn Congress appropriated nine million dollars to finance an engineering defense training program to be conducted in qualified colleges under the auspices of the United States Office of Education. This appropriation was in addition to an earlier one of sixteen million dollars for training of mechanics and technicians in the trade schools and technical high schools of the country. The engineering college program is now in full swing, and over four hundred intensive courses are being given in nearly one hundred institutions throughout the country. Each of these courses is specially designed to train students for service with manufacturers or Federal agencies in capacities of engineers, designers, operators of technical equipment, inspectors, or supervisors of production. On last report about seventy-four thousand students were enrolled to study for these positions.

The Institute's work in this field is part of a larger local program which has been co-operatively organized, under the United States Office of Education, by the four schools offering engineering education in metropolitan Boston — M.I.T., Harvard, Tufts, and Northeastern. The M.I.T. itself has offered fifteen special courses, and by summer's end nearly one thousand students will have completed the courses.

Apart from this special defense training program, M.I.T. is offering other types of defense training to regularly registered students. For many years the United States Navy has sent to the Institute a group of young naval officers for postgraduate study, particularly in the field of naval construction. At the request of the Navy Department we have established a new program which combines separate courses in naval construction and naval engineering into a single co-ordinated program. Of the sixty officers who have been detailed here during the academic year, forty have been taking the three-year program, and the remainder have been studying in the fields of meteorology, electrical engineering, mechanical engineering, and aeronautical engineering.

Weather forecasting has become an essential feature of modern warfare, and for a number of years M.I.T. has been giving postgraduate training in weather forecasting to young men sent to us by the Army, Navy, and weather bureau. But now the national defense needs demand a very great increase in the number of men trained in this highly specialized field and in modern methods but recently developed, in which instruction is available at only about five institutions in this country.

M.I.T. Photos

1921 debates: Edmund G. Farrand of Chicago, Carole A. Clarke of New York. — John E. Burchard, '23, and Herbert L. Beckwith, '26, loading up. — William R. Thomas, '87, Godfrey L. Cabot, '81, N. P. Ames Carter, '87, Frederick A. Kendall, '87, Giles Taintor, '87, Winthrop Cole, '87, Mrs. Carter, and Frank F. Tripp, '87, in discussion.

THESE BUILDINGS DEDICATED IN THE YEAR NINETEEN
HUNDRED SIXTEEN STAND AS AN ENDURING MONUMENT TO
RICHARD COCKBURN MACLAURIN
WHOSE ENERGY VISION AND LEADERSHIP AS PRESIDENT
FROM NINETEEN HUNDRED NINE TO NINETEEN HUNDRED
TWENTY ESTABLISHED THE MASSACHUSETTS INSTITUTE
OF TECHNOLOGY IN THIS MORE AMPLE HOME AND GUIDED
IT INTO A NEW ERA OF STRENGTH AND STABILITY

M.I.T. Photo

The memorial inscription to President Maclaurin presented by the Class of 1916

Last summer a special intensive course was given to recruits from the meteorological service and the Army Air Corps. During the year just closed we have had another group of approximately sixty special postgraduate students in this subject, training for the Army Air Corps and the weather bureau; the course is to be repeated beginning July 1 and extending through next January.

The largest of the Institute's activities in the national defense field is its research program. At the present time sixty-three separate contracts for research and development are in force. Several of the contracts include more than one project, so that the number of individual researches under way is over seventy. Of the sixty-three contracts at present on the books, thirty-six are with government agencies and the remaining twenty-seven with industrial firms.

The magnitude of our research program is indicated by the direct and indirect expenditures for this purpose, which are exceeding two million dollars during the year, and by the size of the staff engaged in it, which may reach three hundred this summer. This corps of expert investigators has been recruited from institutions throughout the country, and most of the men have been generously given leaves of absence from their institutions.

The total expenditures involved in defense research at Technology are approximately two-thirds of the Institute's normal annual operating budget, and the personnel needed has required an increase in our staff of approximately 50 per cent.

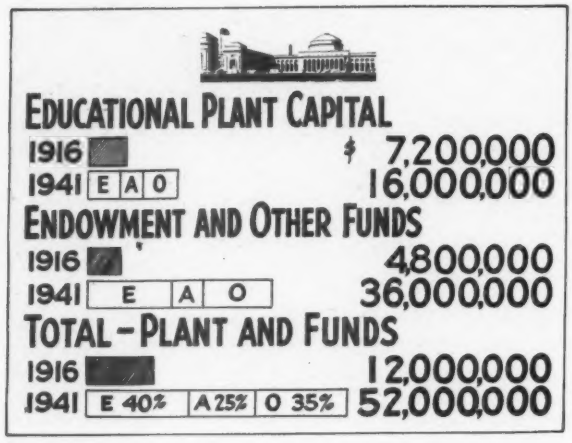
To house this program has demanded extensive re-adjustments in our space assignments and the most intensive use possible of our buildings. Last March we completed a small storage building to take care of the needs of our Department of Military Science and Tactics and to relieve congestion in the main buildings. Hardly was it finished when we found that we had to devote a portion of it to special national defense research. Defense needs also prompted the Corporation to authorize the construction of a new building for chemical engineering. In response to defense needs we have allotted or begun construction on 86,000 square feet of space, an area roughly equivalent to the space in the William Barton Rogers Building.

Naturally nothing can be said in regard to the subjects or the objectives of this defense research, and exceptional precautions and safeguards have been put into effect to preserve the confidential character of the work and to insure the loyalty and discretion of those engaged in it. I should not feel justified in giving even this over-all statistical picture were it not for the fact that it can be no secret that M.I.T., along with a hundred other educational institutions and a great number of industrial organizations, is actively working on the technological aspects of this great national defense effort. The alert layman need but reflect upon some of the acute technical problems which have been presented by the war abroad to guess the directions of some of the research and to realize its urgent importance.

I feel justified, too, in pointing to what is being done as a striking example of the national usefulness of an institution such as ours. The extent to which Technology has been called upon is an index, I think it is fair to say, of our superb resources

M.I.T. Photo — Courtesy Boston Globe — M.I.T. Photo

B. Edwin Hutchinson, '09, President-elect of the Alumni Association, and Mrs. Hutchinson chat with Charles T. Main, '76. — Three from 1873: George M. Tompson of Wakefield, Henry P. Cogswell of Wenham, and William T. Leman of St. Petersburg, Fla. — William F. Rivers, '26, back from Calcutta for an interlude, talks things over with classmate James R. Killian, Jr.



E A O equal Eastman, Alumni, Other in this representative sample of the graphic material vitalized by Treasurer Horace S. Ford at the Alumni Day dinner.

of staff and facilities, of the fundamental importance of our program, and of the recognized availability of these assets for national service. Since it was founded, the Institute has had no reason to change its basic objectives, whether in times of prosperity or of depression, of peace or of war. Its contribution in this defense emergency is simply a dramatic demonstration of its vitality and accomplishment in peacetime and of the growing value of science and technology as the foundations of national strength and the mainsprings of future progress.

The national usefulness of the Institute requires further that normal educational work continue with as little disturbance as possible. That it is so doing was emphasized by Dr. Compton's summary of the ways in which the Institute's full program is being maintained. Important gains toward this end include the new laboratory, which will remove restrictions from the full potentialities of the Department of Chemical Engineering; the dental clinic, which will augment the effectiveness of the Medical Department; and the authorization of the new degree of doctor of philosophy in industrial economics.

. . . *Means to an End* . . .

Dr. Compton's opening allusion to the past may well focus consideration on the impressive part of the Alumni Day program which was concerned with Technology tradition — of special import on this twenty-fifth anniversary of the Institute's establishment in its present home. Unveiling and dedication of an inscription honoring Richard Cockburn Maclaurin, seventh President of the Institute, were the central event of this portion of the day's festivities. Cut in the east wall of the Main Lobby, the inscription was presented to the Institute by the twenty-five year Class of 1916 as its reunion gift. The ceremonies attending the dedication were simple and impressive. Presiding was Edwin S. Webster, '88, of the Corporation, who was president of the Alumni Association in 1909 when Dr. Maclaurin was elected Institute president. In opening the exercises, Mr. Webster emphasized Dr. Maclaurin's "fundamental preoccupation with advancing the Institute into new regions of science and engineering, improving its efficiency in teaching, and broadening its service to the country."

Jerome C. Hunsaker, '12, introduced as having pioneered, with Dr. Maclaurin's support, in the first instruction in aeronautical engineering at an American educational institution, stressed Dr. Maclaurin's wide knowledge of educational systems, saying in part:

Richard Maclaurin accepted the leadership of the Institute only after a searching examination of its educational methods and objectives. To this examination he brought extraordinary scientific competence, a knowledge of the educational systems of three continents, and an understanding of human values as evolved in the basic structure of the law. Maclaurin found in William Barton Rogers' concept of the concurrent pursuit of general education and professional training an opportunity to practice a doctrine he once quoted from Carlyle: "The end of man is an action and not a thought, though it were the noblest." He also found that the problem of carrying out a scheme of learning by doing had become enormously complicated since Rogers' day by the vast increase of scientific knowledge and its manifold engineering applications. In fact, Maclaurin found the problem had grown quite beyond Technology's facilities and finances. . . .

M.I.T. Photos

Robert E. Wilson, '16, commencement speaker, with Mrs. Wilson. — The alfresco buffet. — Charles E. Smith, '00. — Welles Bosworth, '39. — Alfred T. Glassett, '20, informs classmate John D. Mitsch of New York affairs.

Nevertheless Maclaurin accepted leadership. He really accepted a challenge to create a new Technology, to make a truly scientific university worthy of America. He accepted this challenge with faith in an educational ideal, faith in a vigorous faculty and alumni body hungry for leadership, and faith in the future of the America with which he had cast his lot.

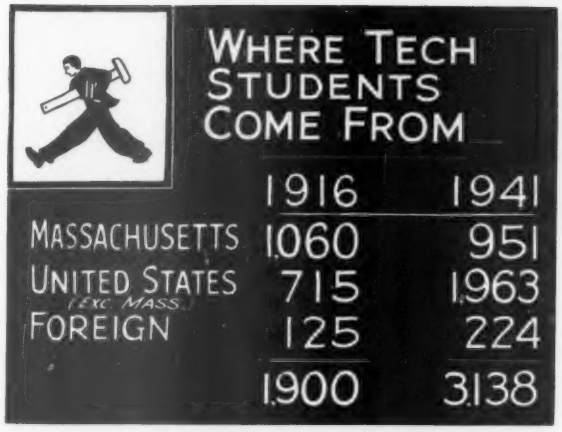
In June, just twenty-five years ago, we dedicated the physical plant of the new Technology, created from Maclaurin's bold and courageous trust in the shape of things to come. Unseen at first to others, this shape of things to come must somehow have been apparent to him, and through him to those who gladly accepted and followed his leadership.

William J. Farthing, President of the Class of 1916, then made the formal presentation of the inscription to the Institute. Sketching the history of Dr. Maclaurin's coming to Technology, of his recognition of the problems posed by the physical limitations of its plant at the time, and of his vigorous attack upon them, Mr. Farthing recalled the participation of his Class in the dedication of the Institute's buildings in 1916. He declared:

That thrilling June day in 1916 found Dr. Maclaurin looking ever forward. He felt that his task had only just begun. He had provided the shell for a great institution — now he must breathe into it the life of scholarship, of accomplishment in the real things that such an institution must stand for. Dr. Maclaurin saw in research the great force that would make man master of his universe — he envisioned technical training as the great instrumentality for putting the research worker's findings at the command of society. And undoubtedly his great success in securing financial assistance rested upon the force and sincerity of these convictions. He made those who were able to help, see how they could through his offices render to their fellow man services that they could never provide through their own efforts.

The inscription was then unveiled by W. Rupert Maclaurin, Dr. Maclaurin's son, who, as associate professor, heads the Industrial Relations Section of the Department of Economics and Social Science.

In accepting the inscription in behalf of the Institute, President Compton paid tribute to Dr. Maclaurin's work for Technology, saying, "Today we are still striving to follow the course he set." President Compton cited several of Dr. Maclaurin's statements of the purposes of education, which he described as standing as beacon lights at the Institute. He offered the affection and admiration of Technology to Mrs. Maclaurin, who, with her sons, William Rupert and Richard Colin, attended the ceremony.



Depiction of another significant change in M.I.T. affairs during the past quarter century, as presented by Treasurer Horace S. Ford at the Alumni Day dinner

Record of other phases of Technology tradition was made on Alumni Day through the presentation of three portraits — those of George F. Swain, '77, long associated with the Department of Civil Engineering and its Head from 1888 to 1909; Everett Morss, '85, member of the Corporation for many years and Treasurer of the Institute from 1921 to 1933; and President Compton.

Mr. Whiting, as chairman of Alumni Day, presided at the dedicatory meeting at which the portraits were presented. Charles B. Breed, '97, Head of the Department of Civil and Sanitary Engineering, speaking of Professor Swain, sketched his career as engineer and

M.I.T. Photos

The Joseph Harringtons, '30 and '96, after luncheon. — 1914 in council: Harold S. Wilkins, Frank J. Jerome, Ernest C. Crocker. — Rogers Lobby, where exhibits centered.

M.I.T. Photo

The Everett Morss portrait presented on Alumni Day

M.I.T. Photo

The portrait of George F. Swain, '77, presented on Alumni Day

educator. Harry J. Carlson, '92, of the Corporation, described Mr. Morss's many services to Technology. Gerard Swope, '95, also a member of the Corporation, spoke in appreciation of the ways in which Technology tradition has been fostered and expanded during the years of Dr. Compton's administration. Mrs. Compton and Miss Jean Compton unveiled the portrait of Dr. Compton, which is the work of Sally de Camp Moffat and was presented to the Institute by Mr. Swope. The portrait of Professor Swain was done by J. Olaf Olson and is the gift of Professor Swain's former students. That of Mr. Morss, which was painted by Gertrude Fiske, came to Technology through the generosity of an anonymous donor.

. . . *Tech Marches On* . . .

In the quarter century marked by the unveiling of the inscription to Dr. Maclaurin, many changes, naturally, have occurred in Technology affairs. In curricula, staff, equipment, student body, student life — that is, in the outward expressions of the inward being of the school — the Institute of 1941 shows differences and changes from 1916. Reviewing these at the dinner concluding Alumni Day was Horace Ford, Treasurer, whose intimate knowledge of Technology is probably exceeded only by his devoted service to its best interests throughout his long association with it. Changes in educational institutions, like changes in almost everything, are in the main measured statistically, and so Mr. Ford was faced with the task of telling a statistical story to seven or eight hundred banqueters after a crowded and enthusiastic day. He was more than equal to the assignment. Chart after chart went on the screen, showing graphically, and with plenty of color, increases in buildings and equipment, increases in funds, changes in make-up of the student body, improvements in student housing, growth of Departments, development of a constantly enhanced recreational program, and increase in numbers and scholarly attainment by the Faculty. Particular emphasis was placed upon the augmented human resources of Technology in staff, students, and Alumni. Charts by themselves, however, mean little. The Treasurer's genial running fire of comment, explanation, description, as it changed pace with his subject matter, made the survey alive and sapient. Throughout, his emphasis was not on mere increase and change as such, but on the fact that in them is to be found the meaning of the past twenty-five years. They have come to be because of the continuing tradition of Technology spirit expressed in the urge to competitive excellence; in the wholehearted co-operation of Corporation, Faculty, Alumni, and friends; in the desire to be of greatest use in time of national emergency; and in the great leadership of such Presidents as Dr. Maclaurin in 1916 and Dr. Compton in 1941.

Implicit in Mr. Ford's story was the quality of goodfellowship which marked the day and about which much could be said. The weatherman actively participated in it. It was conspicuous in the reminiscent gatherings at the luncheon in Du Pont Court, and was undernote throughout the address of the fifty-year-class speaker, Henry A. Fiske, '91, at the Class Day exercises which followed. Thomas D'Arcy Brophy, '16, spoke for the twenty-five-year class. The customary exercises were witnessed by a large number of spectators and were well received. The concluding dinner, satisfy-

ing in its bill of fare, was marked by a unity of spirit notable in Technology events — a unity well expressed in the singing of "Mens et Manus," written by Gordon M. Fair, '16, the last two verses of which were prepared in anticipation of the twenty-fifth reunion of the Class of 1916 and which were dedicated to the memory of Henry Greenleaf Pearson, who served for many years as head of the Institute's Department of English and History.

. . . *Allies* . . .

The Alumni Day conference this year had as its subject, "Science and Engineering as Allies of Medicine," which was discussed by Dr. Frank H. Lahey of Boston, Professor George R. Harrison of the Institute, and Professor Detlev W. Bronk of Cornell University Medical College, whose papers appear elsewhere in this edition of The Review. Samuel C. Prescott, '94, Dean of Science at Technology, presided. Huntington Hall was thronged for the session, which, in its clear delineation of the unity of scientific activity, was especially appropriate to the day.

Supporting the discussions presented in the conference were extensive exhibits in the Main and Rogers lobbies showing apparatus developed by scientists and engineers for use in the diagnosis and cure of disease. The exhibits elicited much comment and attention.

M.I.T. Photo

The George Owen Trophy

Tribute of a Trophy

THE Inter-Collegiate Yacht Racing Association recently placed in competition the George Owen Trophy, which has a significance far deeper than its importance as a prize in the annual Eastern College Dinghy Regatta. By those who know yachting, the new trophy is at once recognized as a very sincere tribute to George Owen, '94, Professor of Naval Architecture at the Institute and designer of yachts, whose name is known wherever sailing is a sport. In particular, the trophy is an expression of appreciation by college yachtsmen for the encouragement and very tangible assistance that George Owen has given to the development of intercollegiate yacht racing. His contribution to the establishment and growth of dinghy sailing at the Institute is already well known, for he designed the Tech-Herreshoff dinghy, of which the M.I.T. Nautical Association now has a fleet of forty, and has actively supported the sport since it was established at the Institute in January, 1936.

The George Owen Trophy is an exceptionally fine half-model of the yacht *Dorello*, one of Professor Owen's most successful designs. Mounted on a walnut plaque bearing an appropriate inscription, the trophy is the work of Elmer H. Peterson, technical instructor in model making in the Institute's Department of Naval Architecture and Marine Engineering.

The *Dorello*, which had no bowsprit and carried a club topsail, was the first of her class, and her rig was later known to yachtsmen as the "Dorello rig." Built by Hodgdon Brothers in Maine in 1908, she quickly claimed the attention of yachtsmen not only for the beauty of her lines but for her racing ability. For the first three years after she was launched she was sailed by Professor Owen, then winning some fifty-eight races out of sixty-two starts. To the present time she has been in almost continual seasonal service, during which she has won many important races.

Corporation Election

THOMAS C. DESMOND, '09, of Newburgh, N. Y., a member of the New York State Senate since 1930, was elected a life member of the Corporation at its meeting on June 10.

Mr. Desmond is a native of Middletown, N. Y., and before his retirement a few years ago was prominent in engineering work in various parts of the country. He was graduated from Harvard University in 1908, and holds the honorary degree of doctor of humane letters, conferred upon him by Union College in 1939. Mr. Desmond is president of Colonial Terraces Corporation and a director of Curtis and Curtis Company. He has been active in politics and professional engineering societies and prominent in Technology alumni affairs for many years.

Graduation

AT the seventy-fourth graduation exercises of the Institute in Symphony Hall on June 10, President Compton awarded 711 degrees to 663 men and 13 young women. More than 95 per cent of the graduating class had already accepted positions, and an almost unlimited number could have been placed had they been available in such fields as meteorology or mechanical, aeronautical, or chemical engineering. (*Concluded on page 458*)

NO SUBTLETIES TO PERPLEX

(*Concluded from page 416*)

inherited most of them and have become used to thinking of them as a matter of course. But they are *not* matters of course; we could lose them in any one of several ways infinitely faster than they were won for us in the first place.

The great threat to our rights — our liberties, our opportunities, our cherished way of life — right now is the threat of domination by the Nazi ideology, carried out by the Nazi organization. And believe me that threat is real to us right here in the United States, to us Technology Alumni in our lives and our jobs! It could come quickly or slowly, directly by force or indirectly through economic competition with essentially slave labor of conquered countries, or through gradual domination of our neighbor countries.

I do not want to appear to be an alarmist, but I do want to say most earnestly what I believe to be true, and I call as my witnesses Czechoslovakia, Poland, Denmark, Norway, Holland, Belgium, France, Rumania, Bulgaria, Yugoslavia, Greece, and any other nations who are rich in resources or strategic location and who have trusted in international honor and justice for their safety. And we know perfectly well that all others will be added to that list who can be conquered or bulldozed into it, and whose acquisition would strengthen or enrich Germany. And this certainly means us to whatever extent Germany may be able to get the better of us — by force or intrigue or fifth column.

So here, in this major problem which faces all Americans today, the issues again are very clear cut: Shall we strive to retain our way of life and all the rights which we have inherited, or shall we let them be stripped from us without serious resistance? Here again the needed virtues are simple and direct: courage, sacrifice, wisdom.

Very rarely have I spoken to urge a course of action or an attitude of mind or emotion. My training as a scientist is against it, and generally I believe in presenting the facts and leaving it to each analytically trained mind to draw its own conclusions and determine its own course of action. And so I do today, except that the issues seem to me to be unusually clear and are certainly unusually important.

Barring a miracle, it appears to me that we shall become involved directly in this war, and that before very long. This is a bare statement of probable fact, based on the trends. In honesty to you I should supplement this by saying that I personally believe that we *ought* to become involved just as soon and in whatever way as will most effectively join our forces to those of Britain in the effort to subdue this nearly world-wide attack on human rights and international decency, before it subdues us. I believe that the Axis powers will subdue Britain and South American countries and cause us at least terrible loss if they are allowed to take us one at a time, as is their habit. So I am forced to believe that all-out aid to Britain is our job, and that the nature of this all-out aid should be whatever will most effectively accomplish the result, without haggling over the phrases "war" or "short of war," and with the throwing of our full national strength into the effort.

You may or may not believe as I do in these matters, and I should not want you to agree with me or anybody else unless your own analysis of the facts and the probabilities leads you to that conclusion. But I do most earnestly hope that you are graduated from this institution with three qualities in your character: first, a high idealism in your relationships with your fellow men; second, courage to follow your ideal; third, wisdom to see how that ideal may be given practical expression, thinking of the future more than of the present.

If you, and all people of America, can have these qualities of idealism, courage, and practical wisdom, then I do not care so much whether Henry Jones or John Smith or Mary Taylor believes this or that particular thing. There will be various opinions on any debatable subject, and this diversity is one of the safeguards and one of the eternal springs of vigor of our democracy. The reason that I do not worry about what specific individuals think, is that I have the greatest of faith in the considered opinion of the majority, provided these qualities of idealism, courage, and wisdom prevail among them. And, in this critical time, the majority will determine our course. True, we have a certain amount of leadership, as every group must have. But this leadership is of our own election and I think I could demonstrate, if it is not already self-evident, that this leadership has not ventured away from what it believed to be the trend of public opinion.

Wherever your role is cast in the coming months, we know that you are equipped by training to be useful in that role. You have varied talents, you are of varied national backgrounds, not all of you are citizens of the United States, though I have been talking to you as if you were. But we are proud of you, just as we are proud of the way in which America has been able to fuse all elements into that versatile, interesting, and capable being which we call "an American." Our ambition is not to purify our race by purging from it the blood of minorities, but to perfect still further the art of cooperative living together in peace, prosperity, and liberal opportunity.

May God's blessing and help go with you as you go on to work, and perhaps to fight, to preserve a social order in which you and I and our children can live in peace, prosperity, and liberal opportunity.

THE TREND OF AFFAIRS

(*Continued from page 414*)

Casts made of this mixture, fired to temperatures of 1,010 degrees Centigrade, shrink as little as a quarter-inch in twelve inches. This shrinkage, approximating that of bronze, is slight enough not to detract from the artistic value of the cast. The strength of objects made from this slip is much greater than that of the Tanagra figurines. Professor Norton, by repeated experiment, found suitable flocculants which made it possible to compound a slip of proper fluidity without the use of a great deal of water. He also discovered that proper timing of the casting operation would allow for absorption of water from the slip (*Concluded on page 438*)

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1. What it is and does

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THE TREND OF AFFAIRS

(*Concluded from page 436*)

by the plaster of the mold. As a result, the cast when removed from the mold contains relatively little water, a fact which contributes to reduction of shrinkage. About ten satisfactory casts can be made from one set of molds before crumbling of the plaster makes new molds necessary.

Each of the advances here touched upon contributes to the rationalizing of ceramic techniques. For estimate of what this aspect of the program means in terms of sculpture, we may well turn to Mr. Demetrios, who finds in it the answer to several dilemmas besetting artists whose honest wish is that their creations may be more widely dispersed among the people than has been possible in the past.

As Mr. Demetrios sees it, the program has provided the sculptor with a means of controlling the production of a work of art all the way from the original modeling to the finished cast which the amateur of art acquires. Working toward bronze, the sculptor generally had to relinquish the casting and finishing operation to a foundry, and hence almost never did the final finishing of the work himself. His share in it consisted of modeling the head, making a plaster mold from the original clay, and producing a plaster cast. This went to the foundry to be cast in bronze. The soundly established technique of using terra cotta instead of bronze means that the artist himself can do the casting and the finishing operation which follows it. Moreover, the terra cotta permits ten reproductions to be made and cuts the cost of making them, thus pointing toward a wider availability of works of art among the people. In addition, the terra cotta which results from Professor Norton's formulas gives the sculptor a medium of a better grain and texture than even that of marble, so that after the cast has been baked, the sculptor can work on it in any direction, giving to the final reproduction the life and vigor attainable only by the direct application of artistic skill and sensitivity. Finally, a wide range of permanent colors is available for the finished piece. Not possible with other mediums, these colors, under accurate control, permit polychrome sculpture, which has been little used by modern artists.

INDIVIDUALS AND INCENTIVES

(*Concluded from page 421*)

regulations on almost every form of business activity. The incentive for the laborer to work hard and get ahead tends to be reduced if he comes to feel that his future welfare is dependent more upon his labor union than upon his own efforts, and if seniority becomes the principal basis for promotion. Bonuses for not raising crops lower the farmer's incentive to work. Even desirable plans such as old-age pensions and work relief tend to reduce the incentive to work if they are carried too far.

The very incentive to invent is threatened by proposed legislation which would greatly reduce the value of a patent. The incentive to save for a rainy day is being attacked and ridiculed by some of our self-styled intellectuals. We must work against such tendencies to weaken incentives if our democracy is to survive.

Management has a large share of responsibility in helping maintain proper incentives for labor and indeed for the entire personnel of business. This problem is not an easy one. Fair wages are, of course, the first fundamental; but money is by no means the only important incentive to the average American worker. Good working conditions, pleasant associates, and an understanding of how his work fits into the whole business help to stimulate interest and enthusiasm in an organization.

By and large I think the greatest thing management can do to provide worth-while incentives for the whole organization is to take every precaution to see that all workers up and down the line are treated fairly, that grievances are handled sympathetically, and that ability is recognized and promotions are made only after careful consideration of all available candidates within the organization.

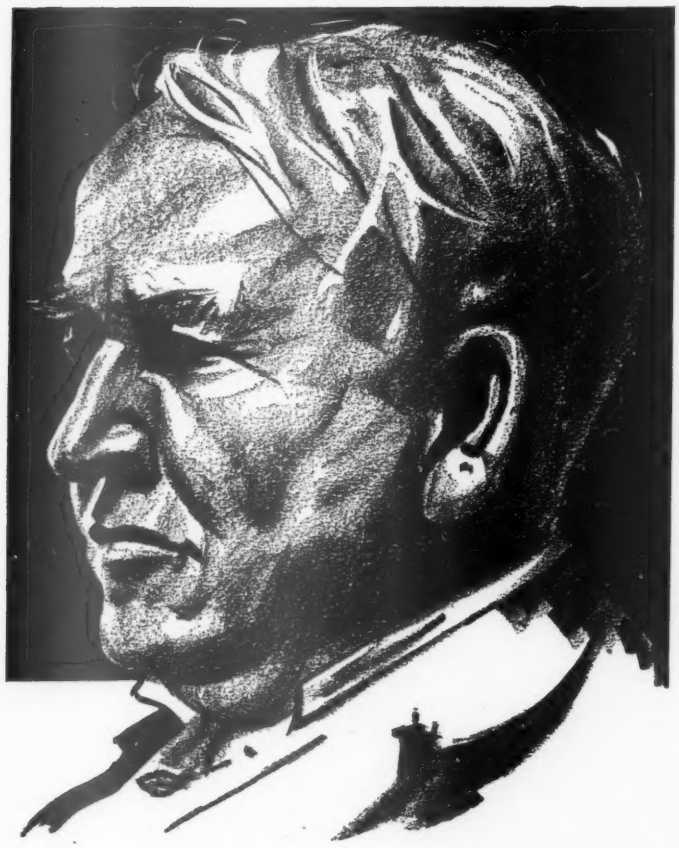
It has always seemed to me that our hereditary instincts are sadly deficient in that, while they spur us to almost superhuman efforts to avoid the loss of a finger or a toe or other relatively unimportant physical member, we seem to have no instinctive sense of the pre-eminent value to us of that spirit of enthusiasm which is fortunately so characteristic of youth. In many individuals enthusiasm gradually atrophies as middle age approaches; small effort is made to nourish it, and little notice is taken of its disappearance. Yet how quickly we recognize the trait when we see it preserved in so many men clear up to a ripe old age, and how much it has to do with both the attainment of success and the enjoyment of life! The unique and vital nature of enthusiasm has long been recognized. Indeed, its very name, from the Greek words *en* and *theos*, literally means "God within." Guard that divine spark as your greatest asset, temper it with judgment and patience, and your rewards will be both material and spiritual.

A BROADER BASE FOR SCIENCE

(*Continued from page 418*)

Needless to say, the gun, the knife, the automobile, and some modern drugs do give the individual bent on crime a wider range, a wider scope. With regard to science and war, however, neither science itself, its method or its spirit, nor scientists as a class can be held responsible for war, ancient or modern. No one denies that modern gadgets, developed out of our scientific understanding, render war more destructive and brutal today. But let me call your attention to the attitude of most of the men of science on this issue by quoting from the minute adopted in 1939 by the American Association for the Advancement of Science. This declaration reads as follows: "*. . . Science is wholly independent of national boundaries and races and creeds and can flourish permanently only where there is peace and intellectual freedom. . . .*"

As to unemployment, I think President Compton made clear not very long ago that, while some inventions may produce temporary unemployment or dislodgment of labor, the total (*Continued on page 440*)



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A BROADER BASE FOR SCIENCE

(*Continued from page 438*)

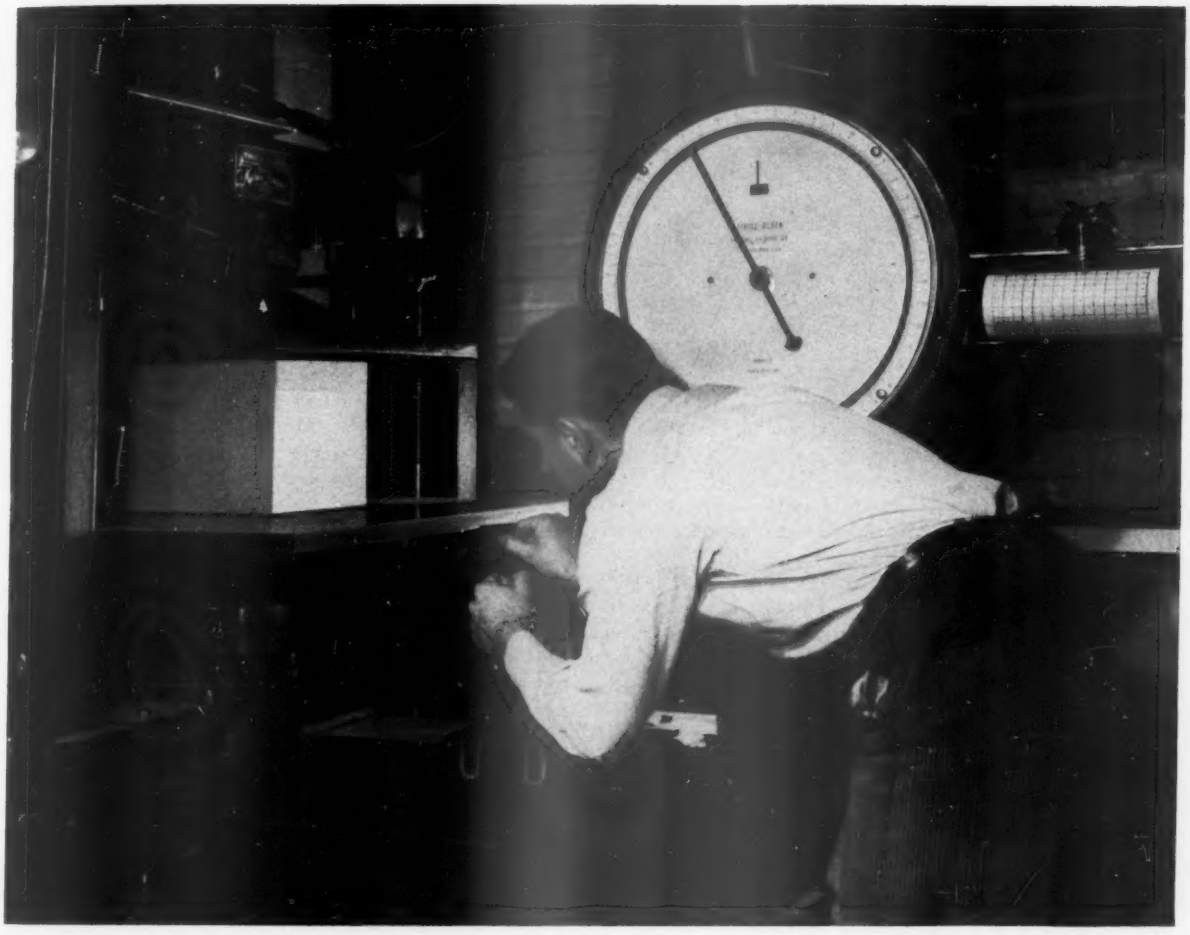
effect of new inventions is to increase employment of labor. Certainly, the growth of cities, inhabited by people not directly engaged in securing sustenance from the soil, would have been absolutely impossible without the inventions stemming from science, both industrial and transportational.

I think the last two charges against science are the most serious, though they reflect less on science and more on man, more on human nature, human selfishness, and human myopia. I think there is no doubt that some gadgets developed through practical applications of scientific knowledge render it possible for myopic man to deplete and waste natural resources at a rate that could not occur by the aid of the bare hands, the crowbar, the spade, the ox, the horse, or the mule. As an example I am thinking of the strip mining of soft coal in my own state of Illinois, where tens of thousands of acres of fertile soil, soil rendered fertile by the processes of nature during perchance more than 100,000 years, are ruined for agriculture, for the production of food and clothing for man, in order to get a few tons of soft coal mined at less expense, for a few pennies of profit for a few individuals. To me, this is not an indictment of science or the application of science; it is an indictment of individual myopia and of social and economic statesmanship in our democracy.

That the applications of science in the growth of modern industries have created a serious individual public health problem under the head of industrial disease, is known to all. Our modern science of medicine is effectively combating this menace, although it is not entirely under control as yet. A sobering thought is the fact that, in the development of industries due to our expanding understanding of nature, man is increasingly and suddenly exposed to chemical substances formerly unknown to him in the whole history of the race or is exposed to substances of injurious potentialities in larger and larger amounts. If we could really establish a broader base for science in society, and by science I include the science of modern medicine and modern preventive medicine, we should soon effectively control this growing hazard. At present we go at things too blindly and we (society and the medical profession) assume that as long as the individual exposed to industrial hazards is not actually sick enough to call a doctor, he is not really injured. Frequently we have discovered, and we shall probably increasingly discover, that this is not the true situation.

To refer again to the charge that science makes war or makes war more violent, I think we may admit that, unless the spirit of science — honesty coupled with the sense of justice and fair play — manages to keep pace with our expanding scientific knowledge and its practical applications, man may destroy himself in days not so very far away, and the insects will rule the world without having to fight man for its possession.

Science is still in the ivory tower to the extent that our laborers, our farmers, and even our leaders in politics, trade, and industry do not understand or at least do not follow the scientific method. Hence I insist that ours is not yet an age of science, (*Continued on page 442*)



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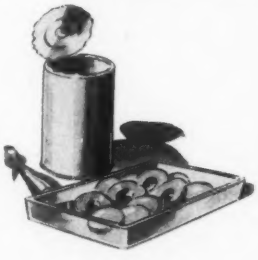

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You may not have realized it, but this is just as true of shipping boxes as it is of canned goods!

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As a result, when you ship in Gaylord boxes, you can be sure that every shipment you make has a better chance of arriving safely . . . and of looking as neat and attractive on arrival as when it left your loading docks.

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CORRUGATED AND SOLID FIBRE

Also Gaylord Folding Cartons . . . Grocery Bags and Sacks . . . Kraft and Specialties

A BROADER BASE FOR SCIENCE

(*Continued from page 440*)

for the character of the age is writ by man's behavior. Men are still driven by greed and confused by guile, rather than guided by reason and justice based on our expanding scientific knowledge. I said on another occasion, but the thought bears repeating here, that science has greatly enlarged man's understanding, conquered many of his diseases, lengthened his life, multiplied his joys, decreased his fears, and added much to his physical comforts and powers. Man may use these and other achievements for a greater social injury instead of for a further social advance. Science is specifically human, in that it stems from the innate curiosity of all men and the conspicuously plastic brains of the ablest, if not the noblest, of our fellows. If this be so, then the scientific method and its products cannot be, in any fundamental and permanent sense, in conflict with human nature, though our present human society, product of a past dominated by greed, force, and fear, may be and is in conflict with the scientific method. Whether science and the scientific method, even on the broader social base for which I plead, can contrive survival values equal if not superior to the blind forces of nature which shaped man's past, is as yet in the laps of the gods. Still, we cannot deny the possibility, and we *will* nurse the hope, that the hairy ape who somehow lost his tail, who grew a brain worth having, who built speech and song out of a hiss and a roar, and who stepped out of the cave to explore and master the universe, may some day conquer his own irrational and myopic behavior toward his kin.

I think we can say, even in the face of current fear and pessimism, that during the ups and downs of past ages, man has through science gradually acquired more understanding and hence more freedom from fear, more dignity, greater kindness, and a clearer conception of justice. Despite the fact that for the moment "the bird of sorrow" is not only flying over our heads but is actually nesting in our hair — to borrow a Chinese proverb — that bird will not nest in our hair forever, even though a blackout on the light of science is decreed in every land. When we have achieved the broader base for science in the understanding of the common man, the method of science will slowly but surely help to make life more intelligent, toil more cheerful, fear, hatred, pain, and tears less prevalent in our lives. If in any place or time the insane violence of war renders the pursuit of science impossible and the scientific method submerged and forgotten, it will be rediscovered in better days by better men. At least up till now man has demonstrated his ability to survive and to reassert his manhood and his intelligence.

The establishment of a broader base for science is too great a task for the handful of scientists in our universities and in our institutions for scientific research, even were these men agreed that this is both an important and a desirable goal. What is called for is the cooperative effort of all men and (*Concluded on page 444*)

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by Westinghouse

• *Every day* elevators transport more people, in any large city, than all other modes of travel combined. Westinghouse elevators alone carry more than eight million people daily.

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• *For many years* our company made the electric motors and control equipment for elevator manufacturers. By 1926 our engineers had become so interested in the many problems of the elevator industry that we began the manufacture of our own elevators.

• *Since then* our people have made three major contributions to comfort and safety in the modern high speed elevator. The first is a power control system that eliminates the jolting stop on the end of a swooping "power dive". No doubt, many stomachs are grateful for this development.

• *Then we developed* that device which automatically levels and stops a car at a desired landing. Remember how the elevator boy used to inch you up and down trying to make a perfect landing? The Inductor Landing which our engineers worked out relieves the operator of this responsibility, simply through the installation of magnetic iron plates at each floor landing and an electric coil on the elevator cab.

• *A third* important development in this field by our company is the so-called "Safe-T-Ray", the photo-electric cell which prevents electric doors from closing until the threshold has been cleared of passengers.

• *If* you have ever ridden on the elevators we made and installed in the RCA Building, New York, you can fully appreciate the comfort, speed and safety of a modern elevator system. In these elevators you have practically no sensation of movement, yet you travel at speeds up to 1400 feet a minute between stops and starts.

• *In the field* of vertical transportation the electric stairway is becoming increasingly important. By conservative estimate more than 30 million people rode on the electric stairways we installed at the New York World's Fair. The Westinghouse Electric Stairways in the Perisphere were the longest ever installed in this country.

• *The elevator engineer* has made the busiest of all transportation systems the safest as well.

• *Elevators today* have an unparalleled safety record. In fact, it is virtually impossible for a passenger to injure himself in a modern elevator.

A BROADER BASE FOR SCIENCE

(*Concluded from page 442*)

women with sufficient training in science to comprehend and follow the scientific method. These are principally the large armies of physicians, industrial chemists, and engineers, and the scattering of competent teachers of science in our secondary schools. Perchance the newly born Association of Scientific Workers will lend a hand. All teachers in our secondary schools, were they themselves conditioned in the spirit of science and aware of the scientific method, could be the spearhead of this advance. The scientific method, the achievement of understanding by controlled experience, has not yet had much of a chance in our formal education, on any level.

We pride ourselves, I think without good grounds, that our age is the "age of science." As Arthur H. Compton recently put it, ours is an age of science only in the sense that the applications of science, the fruits of science, influence our external mode of living, both in peace and in war, to a much greater extent than they have at any other period in human history. But even today guile and deceit, violence and war, hate and vanity — the very antitheses of science, the very negations of the method and the spirit of science — are just as rampant as in the days of the cave man and the saber-toothed tiger.

When the twilight beckons men of my years, we still have our children, we still have our dreams. I dream of a day when through social experience in science and justice we shall actually put the principles of democracy to work within our land — in politics, in industry, in trade, in education; when understanding and kindness will more than hold their own against guile and greed; when force and violence are replaced by conference, compromise, and approximate justice in all our domestic relations. When that day is at hand in our own land, our example will be a greater impetus to science, peace, and justice in other lands than are our present speeches and our lend and lease of the implements of violence and war to all present and potential democracies of the world. For then we at least will be strong enough to fear no ill wind from across any ocean, strong enough to maintain our own ways of life, a life worth living for a million years.

ARMING THE PHYSICIAN

(*Continued from page 425*)

apart. Hence a factor of 2.5 still exists between present realization and that which can conceivably be reached with the existing instrument.

Will the physician be satisfied with the present realization? No. With a possible factor 2.5 times better? Yes. After all, there must be a lower limit to the size of living matter, for all bacilli, like all men, are made of atoms. We know that atoms are about four-billionths of an inch in diameter. Since (*Continued on page 446*)

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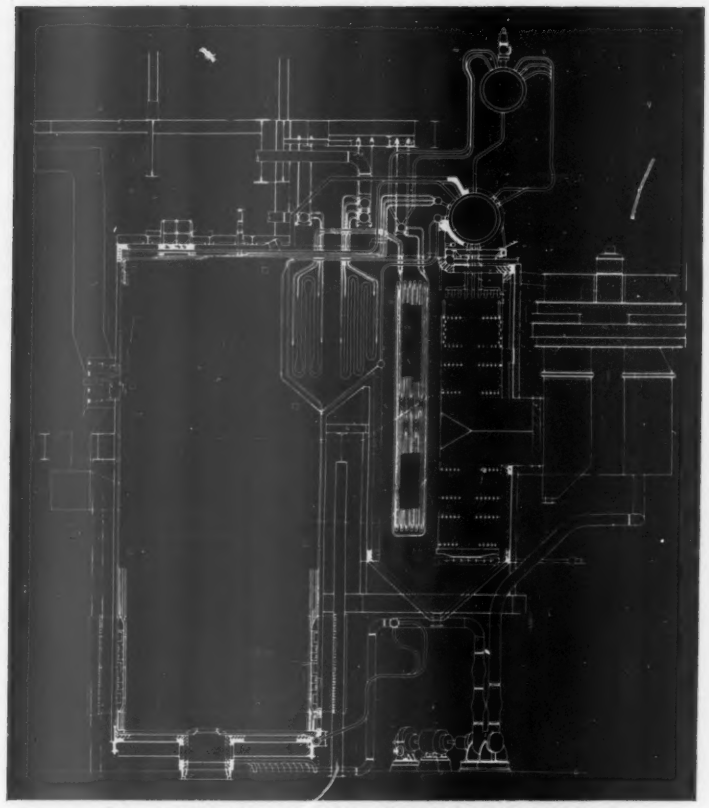

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Now being installed at Montaup. For details, see text.

In many sections of the country, power stations have been modernizing and expanding their facilities with C-E high-pressure, high-capacity, steam generating units. Take New England, for example — a particularly appropriate selection for the readers of Technology Review and known to all those familiar with progress in steam power engineering as the site of the first installation to produce steam at a pressure as high as 1200 lb per sq in. New England's largest power stations have been taking full advantage of progress in steam power practice by selecting C-E high-pressure units for their latest installations as listed opposite.

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"L" Street Station, Boston, Mass.
One Unit
Capacity—542,000 lb of steam per hr
Design Pressure—1400 p.s.i. Temp—910 F
Mystic Station, Everett, Mass.
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Capacity—430,000 lb of steam per hr
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CONNECTICUT LIGHT AND POWER CO.
Montville Station, Montville, Conn.
Two Units
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Devon Station, Devon, Conn.
Two Units
Capacity—225,000 lb of steam per hr
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MONTAUP ELECTRIC COMPANY
Somerset Station, Somerset, Mass.
One Unit
Capacity—650,000 lb of steam per hr
Design Pressure—2000 p.s.i. Temp—960 F

NARRAGANSETT ELECTRIC COMPANY
Manchester St. Station, Providence, R. I.
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Design Pressure—1350 p.s.i. Temp—915 F

One of these installations brings to New England the distinction of having the first high-pressure, high-capacity, *forced-circulation* boiler unit in the United States and the largest boiler of this type in the world. This unit marks the biggest step forward in steam generation since pulverized coal firing and water-cooled furnaces — also pioneered by Combustion Engineering — revolutionized steam generating practice some twenty years ago. Now being installed at Somerset by the Montaup Electric Co., this C-E Forced Circulation Unit points the way to the most significant future development in the field of high pressure steam generation.

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WHERE PRINTING IS
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ARMING THE PHYSICIAN

(*Continued from page 444*)

several atoms are needed to make a molecule, molecules are certainly larger than atoms. The smallest living unit must be at least as large as a moderately complex molecule; so we can set twenty-billionths to forty-billionths of an inch as the probable lower limit of the size of living matter. Thus we find the electron microscope on the verge of fulfilling all the needs of the physician for the photography of small living objects. Although much needs to be done, most of the problems which remain are of the character of biological engineering.

The spectrograph is a much older instrument than the electron microscope, but only recently has its extensive applicability to medicine been realized. Primarily an analytical instrument, the spectrograph can be used for measuring the presence of metallic constituents in the blood, the potency of vitamins, the activity of hormones, and for similar problems involving the determination of very small concentrations of material.

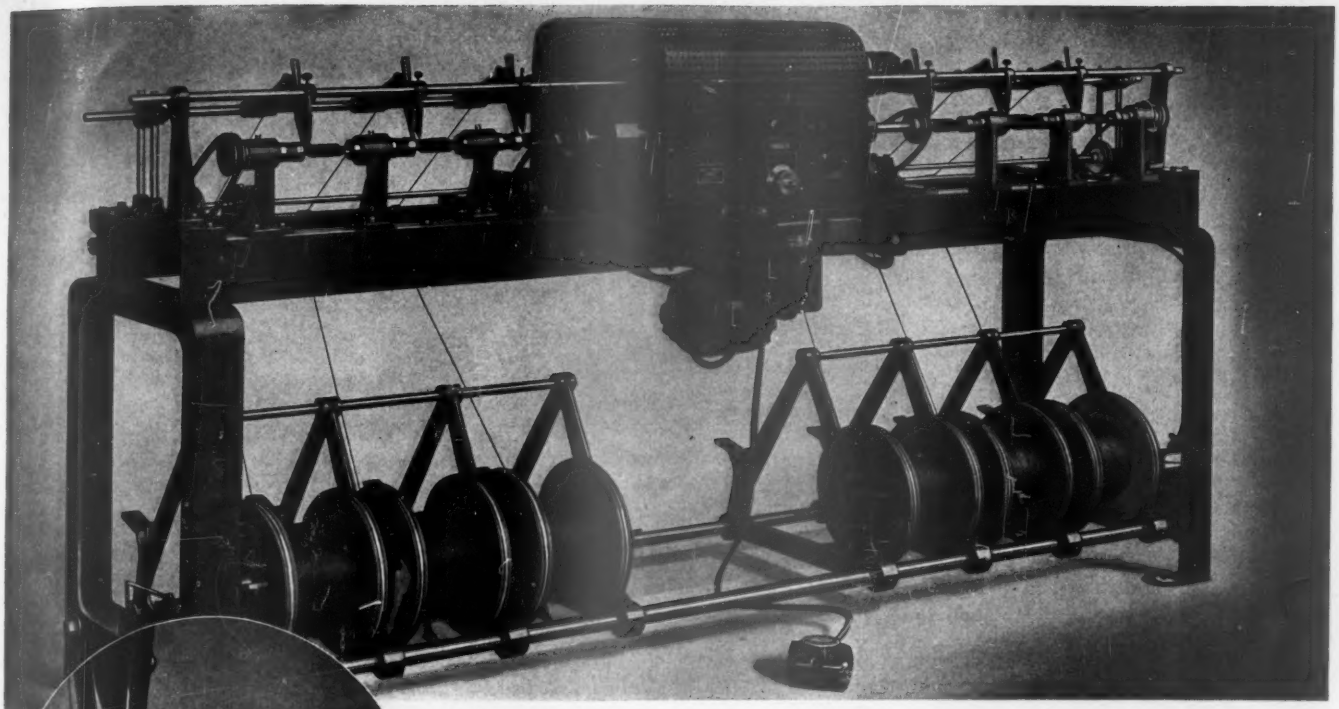
The basic principle of the spectrograph is that it detects the light which atoms and molecules can be made to emit and with this light produces spectrum lines which are arranged in such simple and reproducible patterns as always to give a definite clue to the kinds of atoms or molecules which have emitted the light, and, somewhat less definitely, to the number of each present.

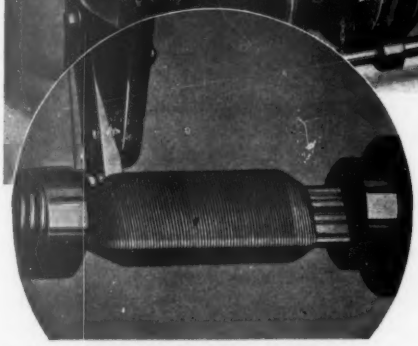
If a physician suspects that a patient is suffering from lead poisoning, he need take only a drop of blood from the patient's ear and burn this blood in an electric arc. The blood, quickly dried by the intense heat of the arc, is burned to ashes, and the very molecules of the ashes themselves are then rent apart into their constituent atoms. The atoms are bombarded by an intense hail of electrons in the arc and are thereby caused to emit light. Any lead atoms present send forth the characteristic light waves of lead, which the spectrograph reveals as spectrum lines in definite locations.

On the same photographic plate the physician records a flash of light sent through the same spectrograph from a drop of normal blood burned in the same arc. He knows the lead content of the normal blood, and by comparing the blackening of the lead lines in the two spectrum photographs is able to determine the amount of lead in the sample taken from his patient. It is possible to measure as little as one atom of lead to a million molecules of blood. In fact, by means of the spectrograph the increase in the lead content of the blood of a person who has slept for one night in a newly painted room can be determined.

The identification of an element depends on the precision with which the spectrograph can determine the wavelengths of the light which the element emits. With the finest type of modern spectrograph, the lengths of these waves can be measured to one part in sixty million. Since the waves are themselves usually less than 1/50,000 of an inch long, the spectrograph can thus be used to make a measurement accurate to one-third of a trillionth of an inch.

When a biological material is burned in an electric arc, the material is destroyed. Analyses of transparent materials, however, can be made (*Continued on page 448*)





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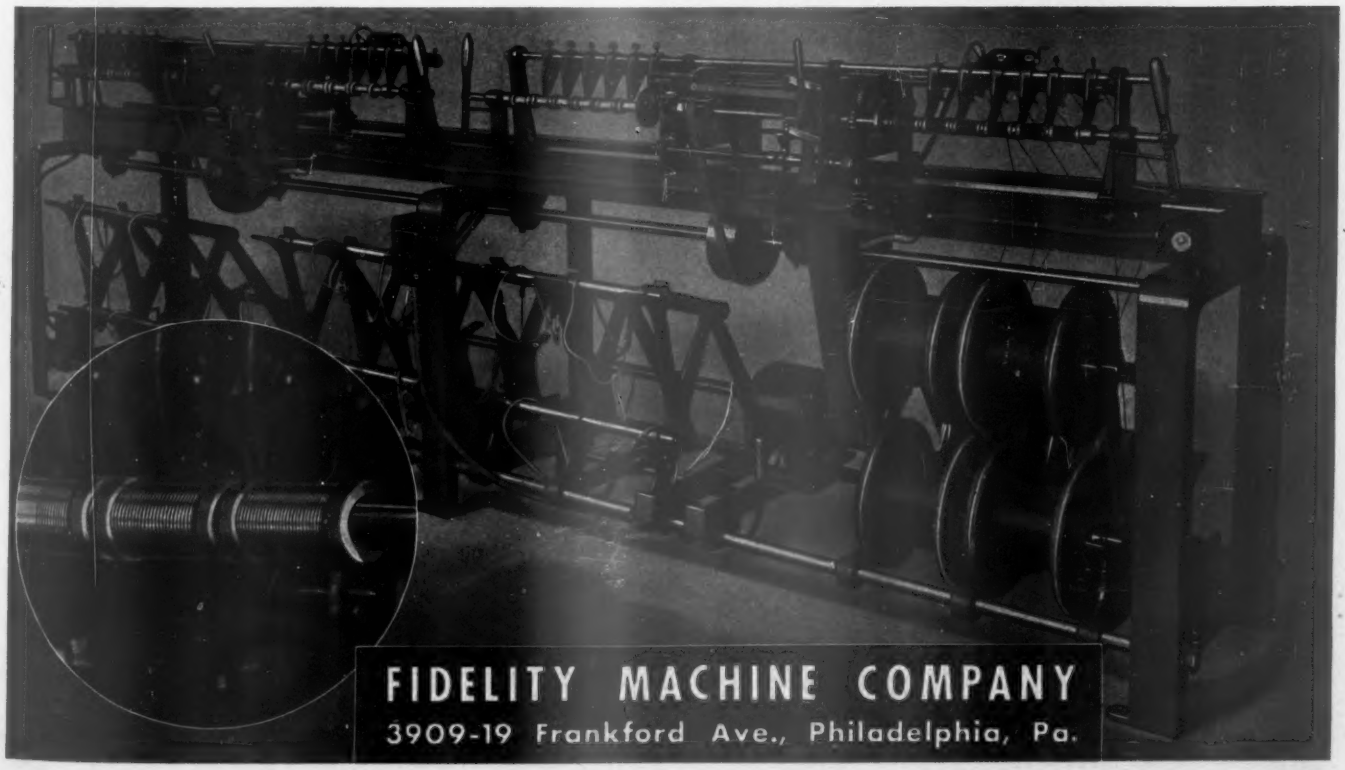


FIDELITY MACHINE COMPANY
3909-19 Frankford Ave., Philadelphia, Pa.

ARMING THE PHYSICIAN

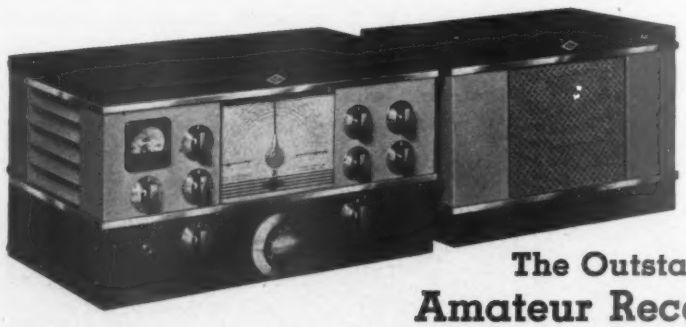
(*Continued from page 446*)

with the spectrograph in a way which does not involve destruction: A beam of light — infrared, visible, or ultraviolet light — is sent through the sample, and the presence of various complex molecules is determined from observation of the absorption of the light of different wavelengths in its passage through the sample. This method has found particular application in the determination of vitamin A in various food materials.

Finally, let us consider devices for the production of atomic rays. Though we are likely to think of an atom as a small sphere about four-billionths of an inch in diameter, actually an atom has proportionately as much empty space in its volume as has the solar system, and atoms are now easy to take apart. Every atom contains a nucleus composed of protons and neutrons, surrounded at appropriate distances by some definite number of electrons between one and ninety-two. To knock electrons out of atoms is quite easy, and is done in every electric arc, neon sign, and radio tube. To knock protons, neutrons, and larger subatomic chunks out of the atomic nucleus is much more difficult, and is what physicists have been engaged in doing in their recent atom-smashing experiments. All of the subatomic particles are extremely small, of the order of forty-quadrillionths of an inch — small bullets, indeed, to hurl at a speed of thousands of miles a second at a target no larger than the bullets. No aiming is possible under these circumstances, of course. A sufficient number of subatomic missiles must be hurled to score, just by probability, the desired number of direct hits on a nucleus. Even if only one bullet out of a million strikes the target, a billion shots will give a thousand hits.

The easiest way to get these minute missiles moving is to make use of the fact that protons, electrons, and the nuclei of atoms in general when stripped of their electrons, are charged electrically. Thus very large electrical forces will be brought to bear on them when they are placed in an intense electric field. In order to allow them to accumulate speed by falling over the electrical precipice which is provided by a high-voltage generator, everything must be cleared out of their path, and the easiest way to do so is to put them in a large closed container and pump out as much of the air as possible. In this way the high-voltage vacuum tube came into being.

The ordinary x-ray tube as used by the physician for taking shadow photographs of bones and other parts of the human body is such a vacuum tube on a small scale. When electrons are slammed at high speed against atoms, x-rays are produced. These x-rays, which are only about 1/4,000 as long as light waves, will burn up any biological material if a sufficient dose is given. For many years physicians have used x-rays in the treatment of malignant cells which must be burned out of the body. The problem is to discover how to burn deep-lying malignant cells without causing the deaths of too many normal cells which will inevitably be struck by the rays. One can obtain a certain degree (*Concluded on page 450*)



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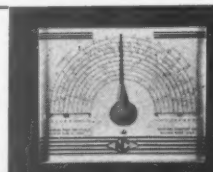

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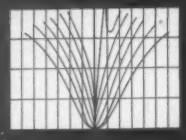

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ARMING THE PHYSICIAN

(*Concluded from page 448*)

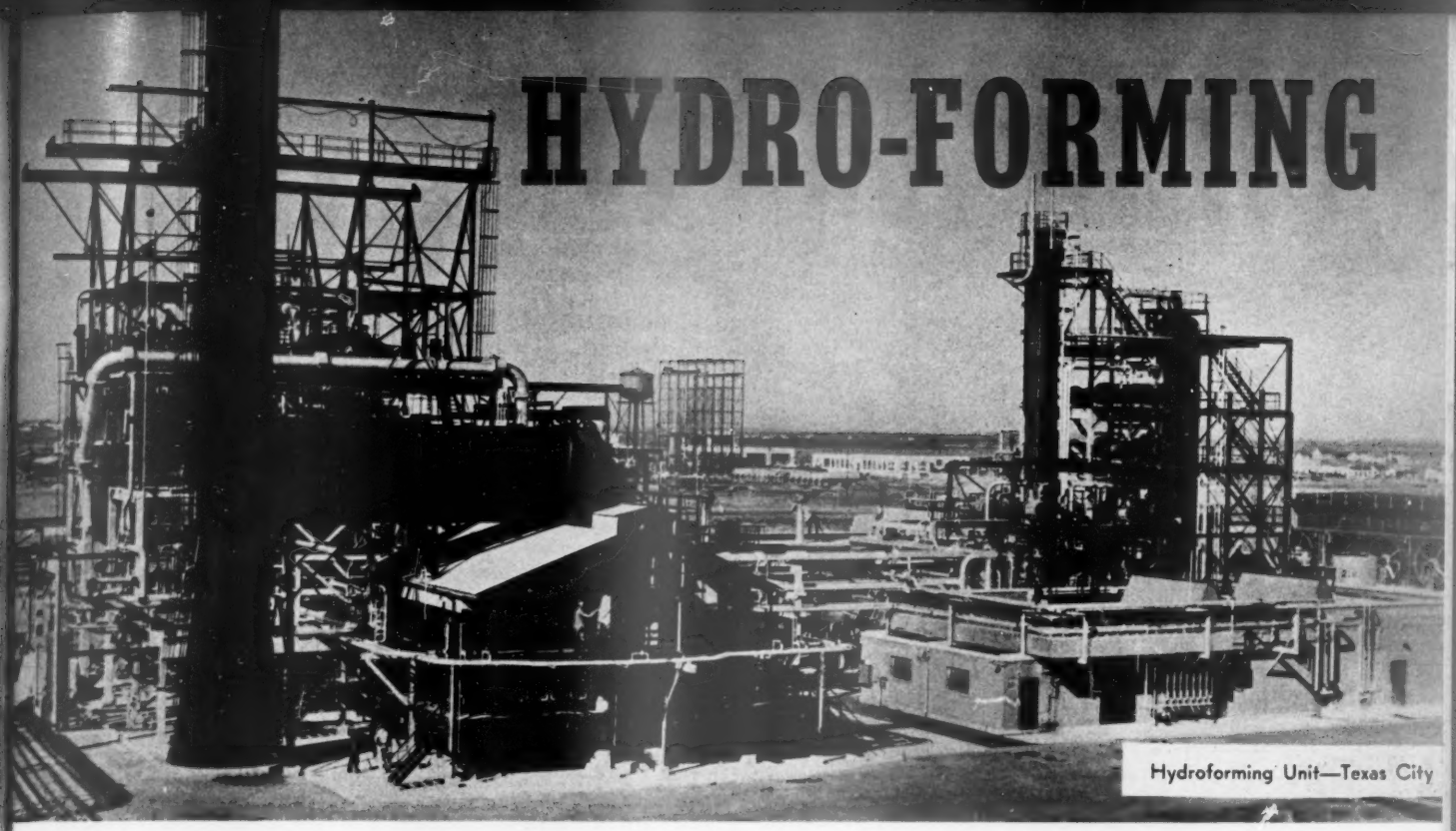
of control by varying the voltage on the x-ray tube. The higher the voltage across the tube, the faster will the electrons move through the tube and the shorter will be the waves of the x-rays produced. The shorter the waves, the more deeply will they penetrate flesh before being absorbed. To reach really deep-lying malignancies, x-ray tubes with millions of volts supplied to their terminals are needed, and these the atom-smashing devices of the physicists have furnished.

Apparently x-rays destroy cells by setting high-speed electrons free in them. The destruction of a cell is believed to occur when the cell is bombarded by a sufficient number of electrons to break up a large number of the molecules in it. It does not matter whether x-rays are used to produce the electrons in the cells, or whether electrons are hurled directly into the cells from vacuum tubes, although the latter method may possibly give improved control over the bombardment. But in order to send electrons directly into cells instead of using x-rays as an intermediary agency, it is necessary to have tubes of much higher voltage.

Radium treatments for malignancies are in reality the same as high-voltage x-ray treatments, inasmuch as the radium atom can be thought of as a small portable x-ray outfit which, when the atom explodes, gives x-rays equivalent to those produced by a tube operated at about three million volts. Radium, however, has many undesirable properties, one of them being that you can never tell when a radium atom is going to blow up. If radium gets into the body, the radium atoms will continue to explode indefinitely; only half will be gone at the end of 1,680 years.

By being bombarded with subatomic particles, ordinary atoms can be transformed into radio-active atoms of new species, which explode quite as violently as, but sooner than, atoms of radium. The medical man can now choose his atom: If he wants a radio-active material that will be half gone in twenty-one minutes, he may choose radio-carbon; for a half life of fifteen hours, radio-sodium is available; and for eighty-eight days, radio-sulphur. Several hundred such atoms have been produced by physicists to date, and new ones appear almost monthly.

Thus the new high-speed atomic-ray devices of the physicist are of great value to the physician. Two lines of development are going on simultaneously: The high-voltage apparatus builds up a great electrical precipice over which subatomic particles can be hurled. The cyclotron, which uses comparatively low electrical pressures, imparts speed to the particle by whirling it in a magnetic field, applying a new impulse each time the particle circles the field. The cyclotron gives the particle velocities equivalent to those which would be obtained in a vacuum tube operating at ten million to twenty million volts. Both the high-voltage generator and the cyclotron are still undergoing improvements. Wherever their development may lead, we can be sure that these devices will be providing the physician with an increasing number and variety of subatomic particles for curative and diagnostic purposes.



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UNION FOR UNDERSTANDING

(*Continued from 427*)

over a nerve, there may be as much as a fortyfold decrease in the electrical resistance of the surface boundary. To physically trained biologists and biologically minded physicists such evidence provides a more definite conception of the nature of the surface of a cell than does a microscopic view of a chemically stained section. These measurements have the further advantage that they can follow the very rapid changes of structure which constitute the life of most cells.

That the altered permeability of the surface of an active cell permits a redistribution of ions which should give rise to a variation of electrical potential across the surface, has been recognized as an empirical fact for generations. The use of the electrical sign of nerve action, however, was restricted to situations in which many nerve cells could be stimulated simultaneously by artificial means in order to develop a measurable potential change. How the sense organs report over their nerve fibers to the brain the state of the environment and how the brain controls the action of the muscles were undeciphered stories until some fifteen years ago. The diverse action among many cells gave a confused record in which the messages in the individual nerve fibers could not be distinguished. When the physicist and engineer provided high-gain vacuum tube amplifiers and rapid oscillographs, the necessary tools were available, and physiologists met the challenge by devising procedures for isolating the single microscopic conducting units going to and from the nervous system. In any one of these conducting units coming from a sense organ or going to the organs of the body there is a rhythmically recurring sequence of impulses. Their frequency, which varies with the intensity of the environmental stimulus, is the code variable in the report from the sensory outposts. Such variations in the frequency and number of these quanta of nerve action also control the muscles of the body. The allied efforts of the physicist and the biologist are thus revealing the nature of the nerve messages which control the organism.

The value of the philosophy of the physicist and his theoretical training to biology and medicine is less generally recognized than is the service of his instruments. If future progress of medical science depends upon the analysis of living structures as physicochemical systems, there must be those who are capable of adapting the theoretical tools and methods of the physicist to the special problems of biology. This is a more difficult task than the mere use of the physicist's instruments because it requires a broad knowledge of both the physical and the medical sciences. The task is made no simpler by the complexity of living structures. But I have seen it accomplished often enough to be persuaded that it is possible.

An increasing number of physicians are making the general problems of normal human biology their major professional concern. Increased (*Continued on page 454*)

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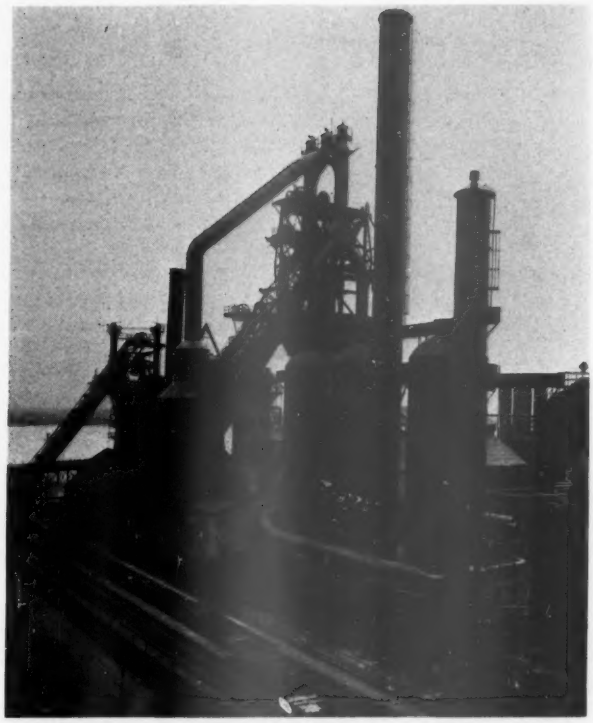

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UNION FOR UNDERSTANDING

(*Continued from page 452*)

emphasis on preventive medicine, on public-health and sanitary engineering, and on industrial hygiene indicates the trend. Engineering and physics will necessarily play a major role in these phases of medicine, and the M.I.T. is in a unique position to lead this movement through its courses in biological engineering and public-health engineering.

The necessity for such an emphasis on the biological requirements of normal man in modern society is partly a result of our increased knowledge concerning the influence of the physical environment on the living organism and has been forced upon us as a direct consequence of the machine age. For, speaking generally, a machine is a device whereby man alters his relations to his natural surroundings. By the greater use of tools and technology, man has rapidly altered his physical surroundings and the conditions which affect his life.

The accomplishments of our technological civilization have been spoken of customarily as "man's conquest of nature." The phrase is an arrogant misrepresentation. Actually, through the physical sciences man has gained an understanding of certain laws describing natural phenomena, and through this understanding has been able to adapt himself more effectively to his environment. He has thus been enabled to utilize natural forces for his needs and his desires. But the value of these developments to man depends not only upon knowledge of the laws of the physical universe but also upon how this knowledge is utilized in relation to the human organism.

There is a gradual realization that the environment and the habits of man have been greatly altered, but with little regard for the well-being of the central figure in the whole drama. I believe, therefore, that future engineers and physicians will join in a greater concern for the relation of man to machines and to the products of machines — of man to a man-made environment. We are being forced to consider the biological results of travel at high velocities and high altitudes, the effects upon a human organism of daily work in gaseous atmospheres unnatural to man or of the new routines of life required by our industrial system. Moreover, architects are beginning to think not only of the materials they employ but of the biological requirements of the living organisms who are to inhabit their structures; city planners adjust their designs to the same needs.

These are signs of real promise for human welfare. They represent the initiation of a movement toward what Lewis Mumford calls the "biotechnic civilization." In order that this movement may be wisely directed, to the end that our knowledge of the material world shall be effectively employed for the well-being of man, we must have a better understanding of the effects of the physical environment upon the living organism. Such an understanding depends upon a knowledge of how the activity of the body is modified by its surroundings. This is the problem of human adaptation. It can be solved only by those of thorough training and broad interest in both the medical and the physical sciences.

(*Concluded on page 456*)

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UNION FOR UNDERSTANDING

(*Concluded from page 454*)

The technological developments that have so profoundly altered the environment and customs of the individual man have also fostered new social and economic systems. The specialization characteristic of modern industry has created new economic relationships between individuals. Changes in methods of transportation and communication have completely transformed the social and political life of man from the day of Plato, who prescribed a population of five thousand as the desirable size of a city because this was the number of persons who could hear the voice of a single orator.

We have, therefore, evolved economically and politically against a background of scientific progress. But not always in this economic and political evolution have we had any very clear conception of the relation of the changing system to the human unit of society. This is, however, an essential relationship, for the contacts of most men with natural forces are largely through the medium of society. Their food supply depends upon the social system, as do their shelter against the elements, their protection against contagious disease or physical violence threatened by their fellows. Thus, the relation of man to his environment is largely determined by the social system of which he is the component unit. Because the functions of the social organism are the integrated activity of groups of human organisms, a more adequate understanding and control of social and economic institutions will be aided by a better understanding of the behavior of man and of the physical forces which determine that behavior. The co-operation of physics and medicine in achieving this understanding will make possible a wiser direction of the future course of our industrial civilization. This relationship is, I believe, the greatest opportunity for mutual influence and co-operative effort which is available to the physicist and the physician.

SCIENCE, ENGINEERING, MEDICINE

(*Continued from page 428*)

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"Describes not only outstanding forms of life that produce light but also the mysteries relating to the chemistry, physiology and physics of animal light." — H. G. Garbedian in the New York *Times* Book Review, February 2, 1941.

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The compiler wishes to thank the following members of the M.I.T. staff for suggestions in the compilation of this list: John R. Loofbourow, Associate Professor of Biophysics; Dr. John W. Williams, Associate Professor of Public Health Laboratory Methods; Robley D. Evans, Associate Professor of Physics; and Marguerite Chamberlain, Eastman Librarian. Copies of this list and the preceding ones may be obtained upon application to the Institute Librarian.

PROGRESS REPORT

(*Concluded from page 423*)

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THE INSTITUTE GAZETTE

(*Concluded from page 435*)

The 676 recipients of degrees included 35 graduates, who, having completed five-year courses, received both bachelor's and master's degrees. In all, 478 bachelor's degrees were awarded, of which 14 were bachelors in architecture; two, bachelors of architecture in city planning; and 462, bachelors of science. Of the bachelors of science, 70 were awarded to graduates of the School of Science and 392 to graduates of the School of Engineering.

The advanced degrees included 22 doctors of philosophy, 25 doctors of science, one master in architecture, two masters in public health, and 183 masters of science. In addition to the academic degrees, five certificates in public health were awarded. Commissions in the Officers' Reserve Corps of the United States Army were awarded to 96 members of the graduating class.

The Gardner Fellowship

HONORING Harry W. Gardner, Professor of Architectural Design, who has been associated with the Institute's School of Architecture since 1895, the year after his graduation, the traveling fellowship of the School was named in May the Harry Wentworth Gardner Traveling Fellowship in Architecture. In making the announcement, Walter R. MacCornack, '03, Dean of the School, declared it appropriate that the fellowship be named "for a man who has given all of his professional life to teaching and who has left such a deep impression on so many architects in America because of his effective teaching and devotion to his work."

Through his long association with the School, his comprehension of its ideals, and his keen judgment, Professor Gardner has exerted wide and beneficial influence on students for years in addition to serving them as their teacher. His profound knowledge of color and design, as well, have been accessible to the Institute, in ways ranging from the decorative themes of commencement and other festivities to the unified color treatment of interiors of Technology's buildings and the decoration of individual rooms. The fellowship which bears his name succeeds the earlier Arthur Rotch Traveling Scholarship.

Finale

ANNUAL reports constituted the bulk of the business before the Alumni Council at its 221st meeting, final one for the academic year, on the last Monday in May. Henry E. Worcester, '97, presided and introduced the officers elected for next year: B. Edwin Hutchinson, '09, President; Harold Bugbee, '20, Vice-President; Herbert S. Cleverdon, '10, and C. Yardley Chittick, '22, executive committeemen.

Speakers of the evening were John E. Burchard, '23, who described life in Washington as the present emergency has affected it; Raymond D. Douglass, '31, who described the national defense courses at the Institute; and President-elect Hutchinson, who discussed national defense work from the industrial point of view.

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Have Accepted Employment	46	95.8	185	96.8	414	93.5	645	94.5
Unclassified	2	4.2	6	3.2	29	6.5	37	5.5
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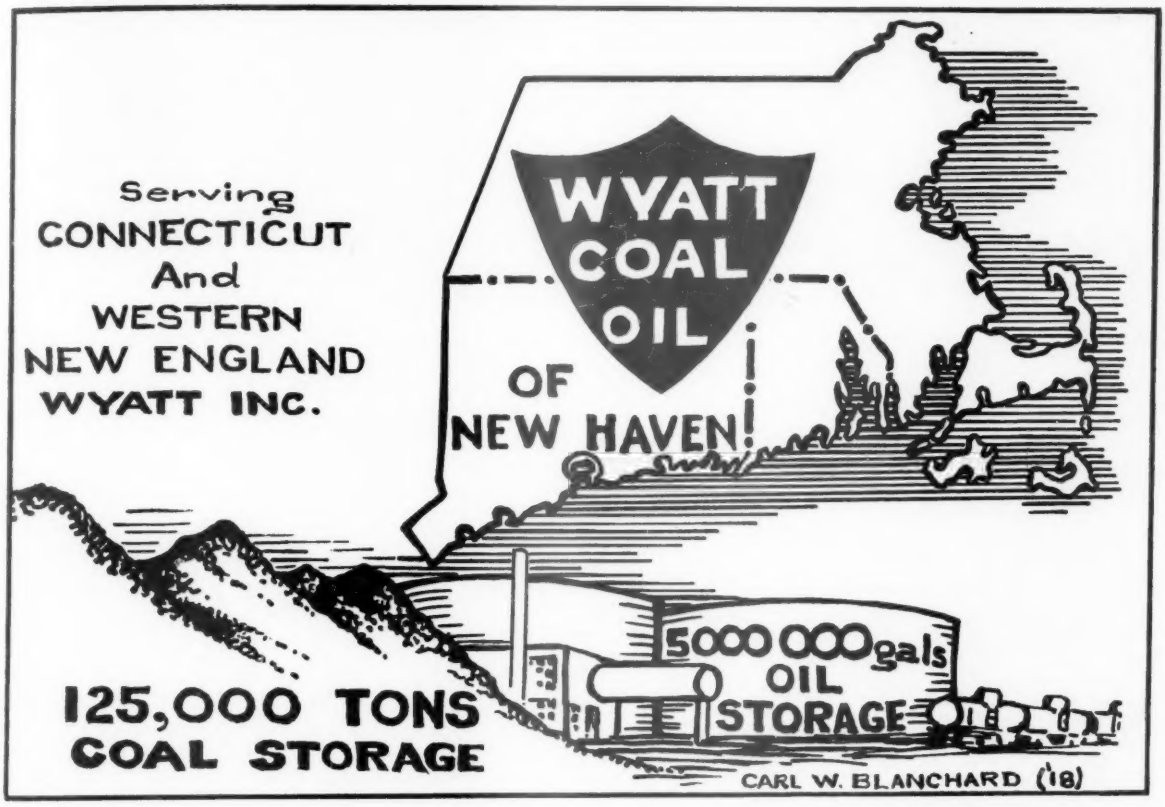

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